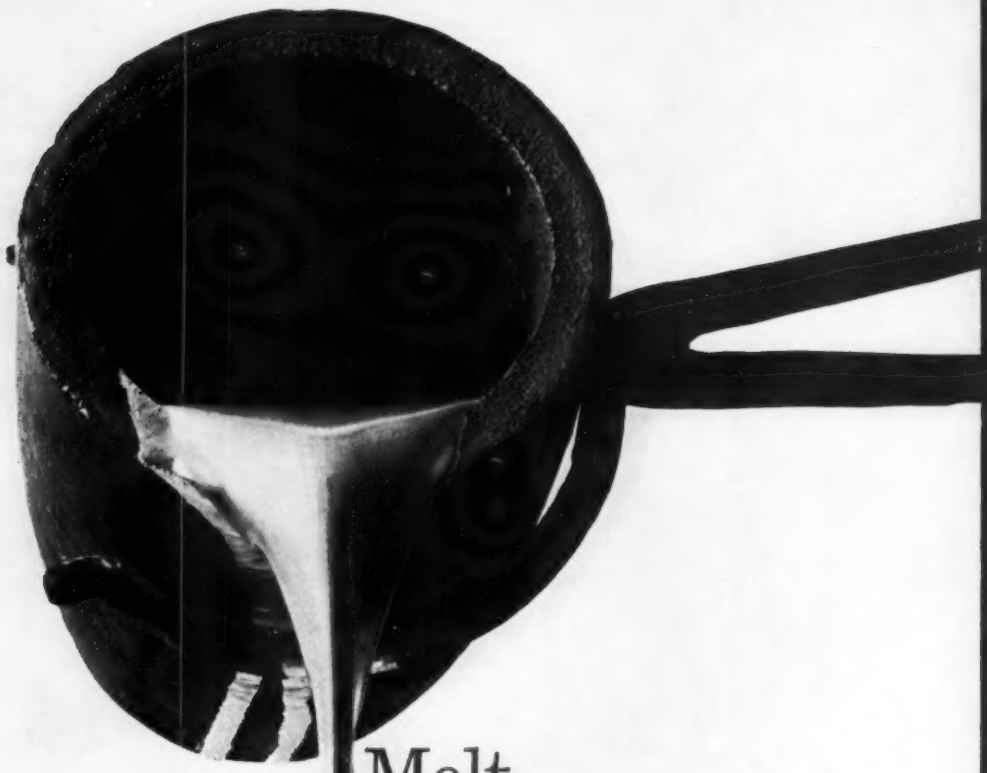
First Production Casting of Uranium 41
Does Your Foundry Qualify? 45
Cost Control through Process Quality Control 110

Space Capsule
Casting
Page 52

the technology-for-profit magazine

modern castings

OCTOBER 1961



Melt aluminum?

Call Olin!

Whether you melt aluminum in 10-lb. lots or by the carload you have access to Olin's casting specialists for information on the latest in improved casting techniques and help in creating the best alloys for your specific purpose. Along with the industry's top brains, Olin Aluminum offers you the industry's top ingots – in 1000-lb. sizes down to the exclusive 10-lb'er. Easily handled and specially adapted for close quantity control these fine-grain ingots are quickly available from mill supply and in less-than-truckload quantities from your nearest Olin Distributor. Whether you want aluminum thinking – or aluminum castings – all you need know is the local Olin phone number.

Olin
ALUMINUM
400 PARK AVE., NEW YORK 22, NEW YORK

NEW

and Priced for Any Foundry Large or Small

Carver RAPID CORE SHOOTER

with Changeable Clamping Device

It took years to perfect . . . but you'll agree it was worth it! New Carver Rapid Core Shooter turns out better cores in amazingly fast time . . . without wear to core boxes, metal or wood. New time-saving flexibility with Changeable Clamping Device enables one man to handle complete operation without turning or unnecessary steps. A **rugged**, reliable machine that handles even the most intricate cores. 100% pneumatic operation — push-button controlled. New hopper provides better sand flow. New type cylinder screen for all fineness of sands. Large air reservoir for much harder ram. Fewer working parts keep maintenance costs at a minimum.

PRICED FOR TODAY'S MARKET

You'll like the speed, the accuracy, the versatility, and above all, THE PRICE. Wait till you see it . . . and don't wait too long. In fact, write today for complete information and prices.

Carver FOUNDRY PRODUCTS
MUSCATINE, IOWA

EVERYTHING FOR THE CO, PROCESS —
Rapid Core Shooter • Rapid Muller • Steinex Binder
Krauss Self-cleaning Taper Slot Core Vents • Automatic Gassing Apparatus

Circle No. 121, Pages 145-146

TRIED INOCULATION ON YOUR PROBLEMS?

With inoculation, you can cure such iron casting ills as chilled edges and machining difficulties. Improved mechanical properties and more consistent metal in all sections can be obtained. Proper inoculation is beneficial to most gray and ductile cast irons. It is a simple, practical and economical practice.

Ohio Ferro-Alloys produces a number of inoculants for a wide range of irons. To find out how inoculation can help solve your problems, needle our Foundry Service Department.

Standard 75% Ferrosilicon • Calcium bearing 75% Ferrosilicon • Low Aluminum 75% Ferrosilicon • Standard 85% Ferrosilicon • Calcium bearing 85% Ferrosilicon • Low Aluminum 85% Ferrosilicon • Low Aluminum Calcium bearing 85% Ferrosilicon • Calcium Silicon

Ohio Ferro-Alloys Corporation
Canton, Ohio

Birmingham • Boston • Chicago • Dayton • Denver • Detroit • Houston • Kansas City • Los Angeles
Minneapolis • Philadelphia • Pittsburgh • St. Louis • Salt Lake City • San Francisco • Seattle • Vancouver, B.C.

Circle No. 123, Pages 145-146

October 1961 Vol. 40, No. 4

modern castings

metalcasting "technology-for-profit"

COVER

Drawn by CHARLES ROTH. More than 21 castings play a vital role in the Mercury space capsule. See story on page 52.

MARKETS AND TRENDS

Ductile Iron—Youngster with a Bright Future ..... JACK H. SCHAUM 53

Castings Play Vital Role in Space Travel ..... STAFF 52

TECHNOLOGY FOR PROFIT

First Success with Cast Uranium ..... D. G. FLECK, B. W. CROCKER, AND G. D. CHANDLEY 41

OPERATIONS FOR PROFIT

You Can Save Money Moving Bulk Materials ..... R. J. GILDEA 48

MANAGEMENT FOR PROFIT

Does Your Foundry Qualify? ..... J. H. RIZLEY 45

SHOP IDEAS FOR PROFIT

Plastic Inserts Reduce Corebox Wear ..... STAFF 50

AFS NEW TECHNOLOGY

Technical Highlights ..... S. C. MASSARI 64

Dust and Vapor Control for Shell Molding Operations ..... ELIJAH B. HENBY 65

Tilt Pouring Permanent Mold Aluminum Castings ..... G. W. STAHL 68

Aluminum Pattern Castings ..... W. E. SICHA 71

Specialty Melting as a Service Function in a Research Laboratory ..... W. F. MOORE 75

Progress in High Strength Aluminum Alloy Castings of Airframes ..... W. A. BAILEY AND E. N. BOSSING 86

High Strength Yellow Brass Castings Weld Repair ..... DONALD K. FOX 89

Molding and Core Sand High Temperature Strength Testing, A New Approach ..... R. W. HEINE, J. S. SCHUMACHER AND E. H. KING 96

As-Cast Cast Iron Compact Graphite ..... R. W. HEINE AND T. W. MUELLER 103

Cost Control Through Process Quality Control ..... C. E. HANEY 110

Cast Nuclear Components Radiography by Means of Kilocurie Cobalt Sources ..... RICHARD LENT 118

How Much Superheat is Lost in the Runner ..... J. W. HLINKA, V. PASCHKIS AND F. S. PUHR 119

Induction Melting and Degassing Installation ..... O. E. ERICKSON 127

NEWS OF THE INDUSTRY

Looking at Business 6

Metalcasting in Washington ..... W. F. FINGAL 9

Around the World 13

AFS Board Gives T&RI Expansion Green Light 36

AFS Convention News 131

Metalcasters Must Sharpen Sales Efforts 141

Metalcasting News 134

AFS Chapter News 142

OPINION MAKERS AND OPINIONS

Marketing and Profits ..... H. E. GREEN 5

From and For the Readers 18

If It Moves, Salute It ..... H. J. WEBER 29

What Next for Apprenticeship Training in Metalcasting? ..... R. E. BETTERLEY 30

The Editor's Forum ..... JACK H. SCHAUM 154

SERVICES

New Books for You	24	Literature Request Card	145
Chapter Meetings	143	Advertisers Index	145
Future Meetings	143	Deaths	147
Metalcasters in the News	144	New Products & Literature	148

Classified Advertising 153

NOVEMBER ISSUE

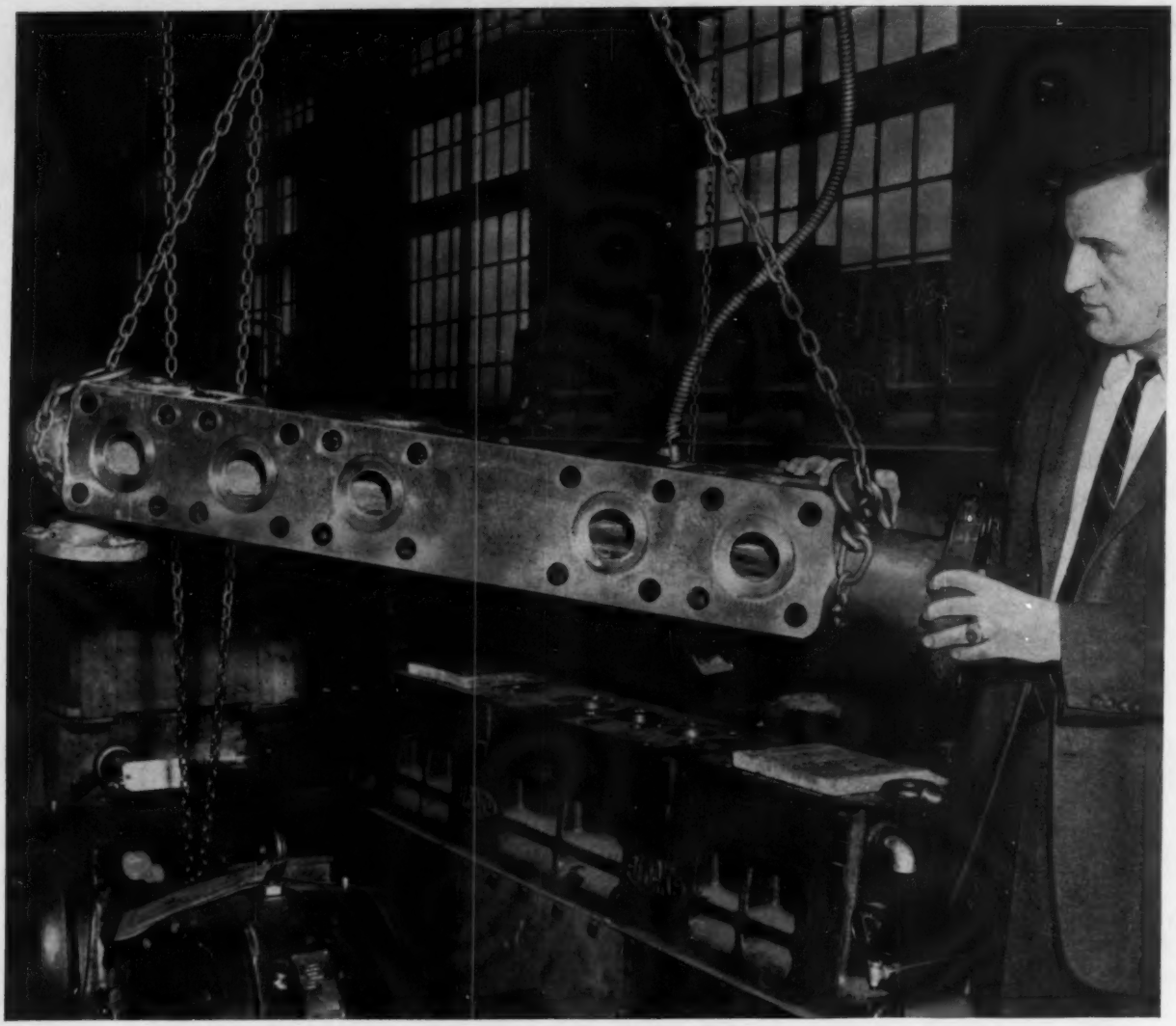
What's Ahead for 1962—Trends Panel Report No. 3

New Ductile Iron Process

Market Opportunities in Ordnance

MODERN CASTINGS is indexed by Engineering Index, Inc., 345 E. 47th St., New York 17, N. Y., and microfilmed by University Microfilms, 313 N. First St., Ann Arbor, Mich.
The American Foundrymen's Society is not responsible for statements or opinions advanced by authors of papers or articles printed in its publications.
Published monthly by the American Foundrymen's Society, Inc. Editorial and executive offices: Golf & Wolf Roads, Des Plaines, Illinois. Subscription price in the U. S., $5.00 per year; elsewhere, $7.50. Single copies 50¢. May and June issues $1.00. Second class postage paid at Lafayette, Indiana. Additional entry at Des Plaines, Ill.

© American Foundrymen's Society 1961.



Why this nickel-aluminum bronze casting handles high-velocity sea water year after year

When this 5% nickel-aluminum bronze fluid end goes into a pump handling high-velocity corrosive sea water, it will out-perform carbon steel 6 to 1, will give service over 4 years, probably more.

Adding nickel together with aluminum means greater strength, greater stability for bronze castings – thus a greater resistance to the combined attack of wear and corrosion, as well as heat.

Moreover, nickel-aluminum bronze eliminates the problems of "dezincification" and "de-aluminization" common to the manganese and aluminum bronzes.

Add to these outstanding properties the fact that 5% Ni-Al bronze also provides exceptional resistance to erosion, cavitation, oxidation, and sulphidization – plus good performance at low temperatures.

Add too, the long service life of this fluid end, and the fact that it will be used in the "as cast" condition. You can see how 5% Ni-Al bronze can be most practical for large castings with diverse contours (ship propellers, machinery frames, pump impellers, etc.) where heat treating could lead to greater production costs and a greater chance for rejects.

This fluid end is just one example of how the nickel-aluminum bronze alloys are providing increased strength and improved wear resistance for a host of cast components. They have a much longer service life than the manganese and aluminum bronzes and, in numerous cases, can be cast without the expense or risk of heat treatment.

If you are interested in readily cast, tin-free, high-strength bronze alloys with exceptional corrosion and heat resistance, write for the booklet, "A Quick Guide to the Nickel-Containing Cast alloys."

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

makes castings perform better longer

modern castings

Golf and Wolf Rds., Des Plaines, Ill.
VAnderbilt 4-0181

Managing Director

HAROLD E. GREEN

Editor

JACK H. SCHAUM

Editorial Staff

ROBERT MINOR, *Managing Editor*
GEORGE A. MOTT, *News Editor*
W. R. FINGAL, *Washington Editor*

S. C. MASSARI, *Technology*
H. J. WEBER, *Safety, Hygiene and Air Pollution Control*
R. E. BETTERLEY, *Education*
M. C. HANSEN, *Castings Congress Papers*

J. S. VANICK, *Contributing Editor*—New York
J. F. WALLACE, *Contributing Editor*—Cleveland
M. C. FLEMINGS, *Contributing Editor*—Boston
W. D. MCMILLAN, *Contributing Editor*—Chicago

Business Staff

GRETA MAXFIELD, *Advertising Sales Liaison*
MARY MCLEAN, *Advertising Production Manager*
DONNA PITKAT, *Reader Service*
MILDRED MICHELS, *Circulation Manager*

District Managers

DWIGHT EARLY & SONS CO.—Midwest
221 N. LaSalle St., Chicago 1
CEntral 6-2184

C. A. LARSON & ASSOC.—Eastern
254 W. 31st St., New York 1
LOngacre 4-4286

PIRNIE & BROWN—South-Southwest
1722 Rhodes-Haverty Bldg.,
Atlanta 3
JAckson 2-8113

DON HARWAY & CO.—Western
336 No. Central Ave., Glendale 3, Calif.
CHapman 5-9421

JOHN ASHCRAFT—European
67 Ave des Champs Elysees
Paris 8, France

Published by

American Foundrymen's Society

GENERAL MANAGER
WM. W. MALONEY

Let's look at . . .

MARKETING AND PROFITS

H. E. Green

ONCE AGAIN I would like to focus your attention on what I consider one of the outstanding industry leadership efforts of the year. It is the series of marketing conferences being held to raise the competitive effectiveness of the industry. (See page 141, this issue.) Here is a proved road to sales and profits. And in this activity can be found advice so sound and basic that all metalcasters should take heed. To paraphrase one of the originators of this marketing conference series (Norman J. Dunbeck, vice president, International Minerals & Chemical Corp.), marketing means more than an upgraded title—from sales.

A. E. Cascino, vice president of marketing, the same company, follows through with specific counsel. Pointing out that marketing is a carefully integrated effort, he says:

"Selling is to marketing what a baseball pitcher is to the team."

And he elaborates on marketing's many parts: planning, organization, coordination, research, training, advertising, pubilicity, sales, sales promotion. For metalcasters there are key aspects, such as:

. . . Value analysis
. . . Creative engineering
. . . Consultants
. . . Sales aids
. . . Laboratory research
. . . Unique product qualities

"Customers *WILL* pay for quality," Cascino affirms. "The metalcaster is like a custom tailor." But he stresses that customer must be offered castings with unique advantageous qualities. Otherwise low price and other methods of fabrication will be considered.

To metalcasters, the basic message of the second Foundry Marketing Conference, as for the first, is that YOU CAN COMPETE TODAY! How much depends on each metalcaster —and how much hustle he has. The means to learn how to market effectively are available.

Harold E Green

Looking at Business with Modern Castings

Now it's official! The metalcasting industry is well on its way to recovery reports Einar A. Borch, vice president, National Metal Abrasives Co., and president, Foundry Equipment Manufacturers Association.

Long a student of metalcasting industry economics, Mr. Borch reveals that the purchasing of capital equipment by metalcasters continues upward. This trend, first noted in the second quarter of this year, remains strong.

FARM EQUIPMENT

The long range picture for farm equipment should be good. Look for improvement in 1962 and 1963. Factors: better economic conditions generally, high net farm income prospects, depleted dealer inventories, and new and more efficient products.

TRUCKS

A 25 per cent increase in the sale of new trucks during the last half of 1961 is anticipated by truck dealers. Largest rise is expected in heavy-duty units. A recent survey reveals that truck retailing is much better than a year ago.

AUTO IMPORTS

New car importers, despite a fall off from 1960 sales, feel that a solid U. S. market continues to exist. The decline has forced revisions in marketing and service programs. Among the changes were new models, price cuts, more dealer assistance, and in some cases the establishing of factory branches.

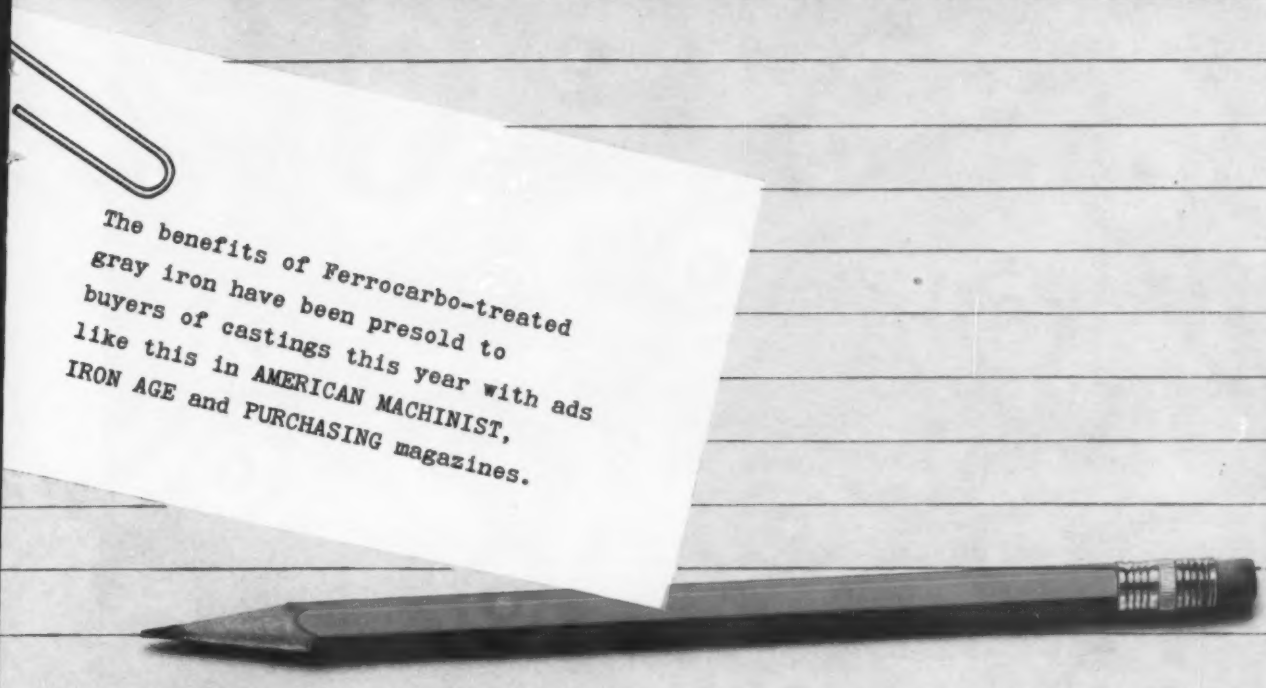
DEFENSE

One of the early signs of Government defense spending is a statement by Studebaker-Packard Corp. that it expects between $30 and $40 million in Federal contracts before the end of the year. The Defense Department wants trucks and it wants them fast. A more immediate impact will be felt by the metalworking industry by the accelerated defense program. Revised defense appropriation for fiscal year 1962 of $46.7 billion is the nation's largest peace-time appropriation. It is anticipated that $16.2 billion will be spent for major procurement and production. Metalcasters can expect a share of new orders in machine tools, materials handling equipment, trucks and motor vehicles, textile machinery, and construction equipment . . . all from Uncle Sam.

MACHINE TOOLS

Two machine tool makers (Warner & Swasey Co. and Norton Co.) indicated the need to raise their prices on some products. Orders have been lagging behind a year ago, officials indicated, and there has been a definite cost-price squeeze.

Lower Your Machining Costs With This Remarkable Tool


The benefits of Ferrocarbo-treated gray iron have been presold to buyers of castings this year with ads like this in AMERICAN MACHINIST, IRON AGE and PURCHASING magazines.

Simply by penciling in a specification for FERROCARBO-treated iron when you order gray-iron castings, you can realize large-scale savings in machining costs. The increased surface machinability of FERROCARBO-treated irons, by independent laboratory test, is 31 to 63 percent. This makes possible savings in the machining of castings that may easily exceed their original cost.

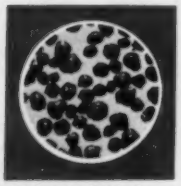
For faster machining, longer tool life and decreased down-time, always specify FERROCARBO-treated castings. They are available from leading foundries everywhere.

FERROCARBO® is a product by **CARBORUNDUM**

Complete technical data on Ferrocarbo is available to your foundries from Kerchner, Marshall & Company, Pittsburgh, Miller and Company, Chicago.

TERMCO AND METAL DON'T MIX

TERMCO—the new, hard, round-grain carbon sand—is solid, inert carbon. It's not wettable by molten metal. Has no sintering point. And expands only ⅛ as much as silica sand! As a result, there's no veining, scabbing, penetration or burn-on. Castings just naturally come cleaner, more accurate, precise. That's why TERMCO cores and molds are the most dependable—especially for the most difficult casting jobs. And TERMCO replaces zircon sand at half the net cost. It weighs only ⅖ as much as zircon and gives you 132 more gallons per ton! Requires no special methods or equipment. Why not get all the facts on TERMCO—now! Send today for more information.



UNRETOUCHED MICROPHOTO

New Molding Medium for Highest Quality Castings

TERMCO®

HUMBLE OIL & REFINING COMPANY • DETROIT 18, MICHIGAN • U.S.PATENT NOS. 2830342, 2830913.

Circle No. 126, Pages 145-146

Metalcasting and Washington

What's Ahead for BDSA?

The Business & Defense Services Administration of the Commerce Department has been reorganized, as predicted, with the combining of some divisions and the creation of two new offices.

One new unit, the Office of Industrial Growth & Research, is concerned with broad technical, economic, and statistical studies of the effect of technological change, automation, mechanization, and basic and applied research on American industry.

The other, the Office of Economic Programs, will initiate broad studies of American industry and business, emphasizing national economic growth and increased production.

What action BDSA will take will be interesting to watch. The agency in the past Administration called itself "the focal point" for industry contact with government . . . Actually it did little . . . Some divisions nothing . . . On the House side, in the Congress, opposition to the agency increased.

On this record, the possibility of helpful action from the BDSA is doubtful, despite changes made . . . These changes by Secretary of Commerce Luther H. Hodges suggest he might be insistent that the agency really do something . . . Hodges has yet to demonstrate himself thoroughly on the side of business, though the Commerce Department's charter states the requirement that the Department "foster, promote, and develop U. S. commerce, manufacturing industries . . ."

In his first few months, Hodges alienated the Business Advisory Council, which was associated with the Department for years as advisers . . . That connection is now broken . . . The BAC's membership includes officials of virtually all the leading iron and steel companies, and many foundry and machine producers . . . Hodges has taken other stands which can hardly be said to "foster, promote, and develop" commerce and industry . . . Watch for anything that might develop out of the realigned BDSA.

No Tax Revision

While the tax-writing House Ways & Means Committee announced that there would be no major tax revision legislation this year . . . majority endorsed the principle of a tax credit to industry against investment in new equipment, as requested by the Administration . . . Chairman Wilbur D. Mills (D., Ark.) explained there was not enough time to conclude work on the overall revision, but that "this legislation will be perfected during the fall months" . . . and . . . "it is hoped that the committee can report to the House by early February."

Because of the tightening world crisis, many observers doubt that the same tax legislation worked on this year can hold up next year . . . As to the tax credit, it will face opposition in the Congress . . . Most industry spokesmen at tax hearings are strongly opposed . . . They prefer direct improvement in depreciation rates . . . This opposition will rise again next year.

Manufacturing About Face

Manufacturing operations at mid-year "turned around briskly" from past winter lows, the Office of Business Economics, Commerce Department, reported . . . Shipments and new orders received, it said, were 8 per cent and 9 per cent, respectively, above January.

Increased market for manufactured goods, stated OBE, stems from enlarged requirements by most major sections of demand . . . Among these are substantial rise in residential housing activity, higher government programs for highways, military construction, and a broad range of defense procurement items . . . Most dynamic source of demand is in the rapidly expanding military expenditure programs . . . Contracts placed in the first five months of 1961 by Defense Department were 11 per cent higher than in the same period last year.

Push Space Programs

No subject has had so many hearings by so many committees in one session of Congress as the United States space program . . . In addition to inquiries into the overall program, one aspect alone — the communications satellite system — has had hearings by several committees.

While inquiries are concerned mainly with military uses of space—and in the case of the communications system that there be no private industry monopoly — various hearings served to point up that there is going to be some massive spending on space efforts.

Estimates run as much as $5 billion a year, and most of that will go to industry suppliers . . . Foundries should see more action as programs increase.

By W. R. Fingal

GREATER SAVINGS FOR YOU WITH

No other molding method can match the advantages offered by the foundry-proved Slinger. Not only does the Slinger offer essential quality advantages, but the Slinger method also provides maximum productive capacity per worker, per dollar, per square foot of floor space. The Slinger offers maximum flexibility in foundries where frequent pattern changes and wide differences in flask sizes are necessary during a day's operation. These changes may be made without interruption to production and this results in appreciable man-hour savings.

B&P SANDSLINGERS®

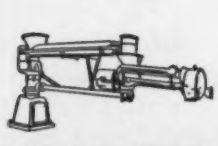
In addition, a wide range of auxiliary equipment such as Rol-A-Draw and Roto-Mold turntable or loop conveyor can be added at any time to extend the productive capacity of your Slinger installation.

For Production or Jobbing Foundries — Sandslingers Provide Outstanding Ramming Capacity — Greater Flexibility

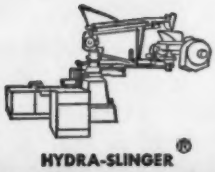
Slingers are not limited as to the mold size that may be rammed. They offer a complete line of Sandslingers, Hydra-Slingers, Speedslingers and Autoslingers that attain ramming capacities of from 700 to over 2000 pounds of sand per minute, assuring productivity not attained by other methods . . . regardless of the basis of comparison.

The Sandslinger's hard uniform ramming assures high mold hardness over the entire pattern face, on vertical as well as horizontal surfaces. Because of the uniformity of Slinger ramming, permeability will be much higher than that accompanying comparable mold hardness attained by other methods. The results are truer-to-pattern castings of more uniform weight and of greatly improved surface quality. Cleaning and finishing costs are markedly reduced, and the elimination of many troublesome defects is favorably reflected in a lowered scrap rate.

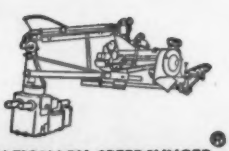
A SLINGER FOR EVERY JOB



STATIONARY SANDSLINGER®



HYDRA-SLINGER®



STATIONARY SPEEDSLINGER®

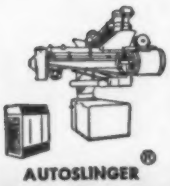
BETTER METHODS FROM B & P RESEARCH

The Slinger is the world's most versatile molding device. No other unit serves as wide a range of application at as low an installation cost. Slingers are very widely used to ram both molds and cores. There is no need to change existing equipment in adapting a foundry operation to the Slinger method. Slingers handle all types of patterns—either wood or metal—and all types of flask equipment.

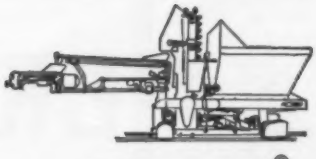
The flexible Slingers can be used independently or with a wide range of auxiliary equipment such as the Rol-A-Draw and roller conveyor or, as shown here, the Roto-Mold turntable. No matter what your requirements, jobbing, semi-production or production, the Slinger either independently or teamed with other equipment will provide quality and productivity unapproached by any other molding method.

Where, due to the size of flasks or other conditions, it is not feasible to move flasks to a ramming station, the Motive Sandslinger, Motive Hydra-Slinger or Motive Speedslinger is recommended. The great range of operation built into these machines makes them truly applicable to the widest possible variety of jobbing foundry production . . . and these Slingers offer ample ramming capacities for the biggest job.

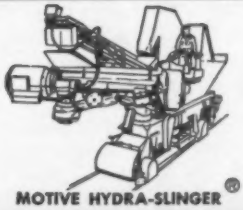
Beardsley & Piper sales representatives are well equipped through training and experience to aid in your selection of a Slinger. These men consider each foundry and its operating conditions before recommending the model of **Sandslinger, Hydra-Slinger, Speedslinger or Autoslinger** to be installed. Their experience, reflected in this recommendation, is an assurance of lasting satisfaction, and this experience together with that of the engineering organization behind them, is at your call—no obligation, of course.



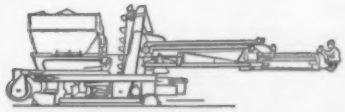
AUTOSLINGER®



MOTIVE SANDSLINGER®



MOTIVE HYDRA-SLINGER®



MOTIVE SPEEDSLINGER®

BEARDSLEY & PIPER Div. of Pettibone Mulliken Corp.
2424 N. Cicero Ave., Chicago 39, Ill.

MEMBER FEMA

Gray iron foundry cuts casting reject rate from 11% to 3%

Line frequency induction superheater improves microstructure and uniformity of melt in critical production of automotive parts

Another major gray iron foundry has solved the problem of excessive rejects when casting to rigid specifications by duplexing with a Brown Boveri electric furnace. Using a 12-ton capacity, 1000 kw induction furnace for superheating 20 tons of gray iron an hour, this foundry (we'll send you their name and installation details on request) now produces metal with better microstructure and near-perfect balance between tensile strength and Brinell hardness. The uniformity of their high-quality thin-wall castings is reflected in substantial metal savings and in the reduction of the reject rate from 11% to a low 3%.

Here's how this single piece of equipment can improve the production output – and the profit picture – of a gray iron foundry. The electric furnace, alone or duplexed with arc furnace or cupola, provides the otherwise missing requirements for quality output: extra-high temperature and precision control for reproduction consistency. Since its heat is generated by induction, local over-heating is eliminated. The stirring effect produces a well-mixed homoggenous melt. And charge after charge is easily and accurately held to identical temperature and make-up, even where demand is irregular and the pouring intermittent.

Find out how these units, available in 1 to 33 ton capacities and suited to even the most automated melting, holding and casting systems, can let you lower your reject rate . . . while raising your profits. If you melt and cast gray iron – or aluminum, for this electric furnace is equally effective in aluminum operations – you'll want to talk to your nearest Brown Boveri representative. Or write us for more information. Dept. MC10. Brown Boveri Corp., 19 Rector Street, New York 6, N. Y.

Brown Boveri offers a full range of line, medium and high frequency coreless and core-type induction furnaces; arc furnaces, resistance furnaces and complete accessories for a perfect mating of equipment to every operating condition and application. When you call on Brown Boveri, you're assured the benefit of 70 years' experience in electrical and mechanical power equipment plus one of the world's most extensive research and development programs in electrics and metallurgy. Full unit responsibility and precise co-ordination of every installation is guaranteed.

BROWN BOVERI

Circle No. 128, Pages 145-146

Around the World with Modern Castings

FORMOSA

What the Russians claimed as a home-developed technique for making ductile iron (MODERN CASTINGS, August, page 11), has been used for three years at the Taiwan Machinery Mfg. Corp. in Kaohsiung. This information was relayed by Hong-Chi Chao, former foundry superintendent, who said he introduced the process in making light weight castings such as power transmission chains. According to Chao, magnesium fluoride and calcium silicide are placed on the ladle bottom and molten iron poured on top of it. The reaction is not violent, and the fluoride serves as an excellent fluxing agent to enhance the inoculation function of the calcium silicide. Hong-Chi Chao is on leave of absence in this country aiming at a Ph.D. from the University of Michigan. More about his process could be learned by writing this magazine.

CANADA

Canada Iron Foundries are working on a $3 million order for cast iron rings used in Toronto's new underground railway. Dual tunnels are lined with 16 foot iron rings—each ring made by bolting together eight curved cast segments measuring two feet long by two feet wide by one inch thick. According to the Toronto Transit Commission, the rings are assembled underground to form a continuous waterproof lining and support for 50 feet of overlying soil. The tunnel is moving ahead at a steady rate of 12 feet every 24 hours. Canada Iron is doing the work at its Toronto foundry, where 160 tons of iron are being used to make 250 cast segments a day.

ITALY

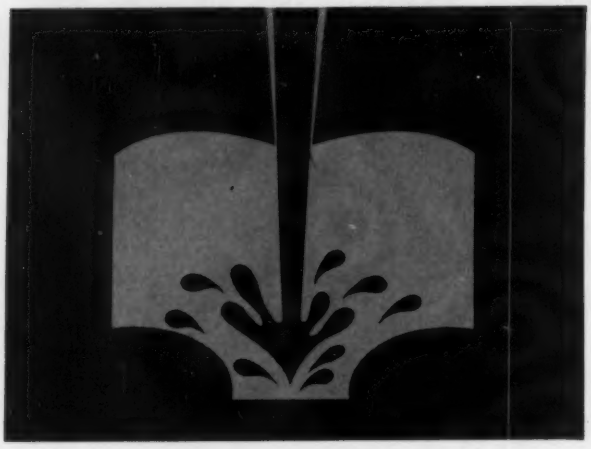
A. Triulzi of Novate Milanese completed tests on a new 2425 ton pressure die casting machine—largest of its type in the world. The machine can produce eight-cylinder aluminum engine blocks weighing 100 pounds each at a rate of 20 per hour. Only one operator is needed; he just pushes a button and dies clamp shut, shot is measured, molten metal injected, die opens, and casting is ejected. This casting behemoth weighs a quarter million pounds and measures 54 feet by 12 feet by 17 feet. Platens are 79 x 83 inches. The complete plant including die casting machine, furnace and die has been commissioned to Triulzi by a U.S.S.R. motor car manufacturing firm. More of

(Continued on page 14)

M&T

OREFRACTION

Zircons make molds tougher



Orefraction Zircon not only removes heat faster, but also withstands temperatures which distort silica sand. It also packs to higher density without reducing permeability, because of its finer, rounder grains.

As a result of this combination of advantages, zircon sand used as a facing eliminates mold erosion from impingement of metals poured through a high sprue. It also avoids fused surfaces and non metallic inclusions.

Use a zircon wash for smoother, cleaner casting surfaces, too. Zircon facing in special areas improves directional solidification. In thin cores, it gives greater dimensional control.

M&T Orefraction Zircon is your assurance of purity and uniformity. Ask us for name of your local Orefraction Zircon distributor.

M&T OREFRACTION PRODUCTS

METAL & THERMIT CORPORATION General Offices: Rahway, N.J.
In Canada: M&T Products of Canada Ltd., Hamilton, Ontario.

Circle No. 129, Pages 145-146

(Continued from page 13)

these die casting machines are being built for European and American industrial organizations.

AUSTRIA

A new patented process makes it possible to use metalcasting to shape cutting tools with a tool life as good or even better than tools made of hot-worked steels. Success hinges on annealing cast tools at 1920°-2190°F for one to eight hours before the usual oil quench and temper. This treatment can be applied to all high-speed steel alloys. Tool life increases remarkably, especially the cobalt containing alloys. Milling tools given the special pre-anneal demonstrated a cutting distance 240 per cent greater than those subjected to conventional heat treatment. Elimination of hot working gives metalcasting a boost in the cutting tool market!

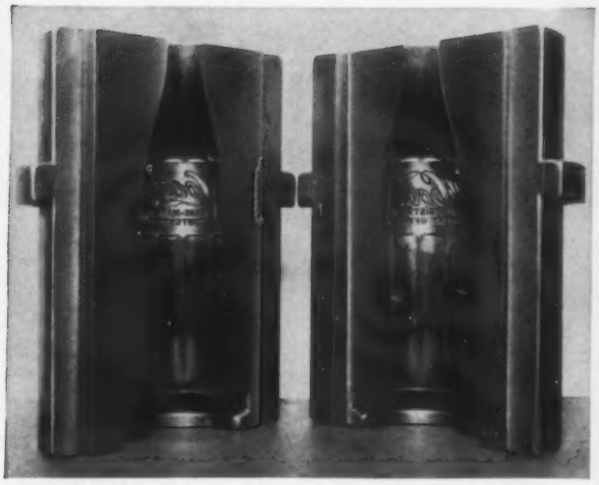
FRANCE

Need for more and better trained foundry technicians here has stimulated opening of a training center at Vierzon. Facilities include sand preparation equipment, various molding machines, a modern coreshop, shell molding department, two-ton-per-hour cupola with automatic charging, a rotating furnace for melting steel and iron, crucible furnaces, three control laboratories, and rather complete mechanical handling. This is one of several schools located in important French foundry areas. In the United States the only comparable training center is planned for construction by the American Foundrymen's Society at its Des Plaines, Illinois headquarters!

RUSSIA

Ductile iron is an acceptable valve material for oil refineries, exceeding carbon steel equipment in corrosion resistance. Valves function satisfactorily in the upper rectifier column for 2000 hours at 700° F and five atmospheres pressure in presence of gasoline vapors, solar oil, hydrogen chloride, and hydrogen sulfide. Ductile iron is also being used for steam fittings at temperatures up to 795° F and pressures of 550 lbs. per square inch. Ductile continues to show its versatile gamut of properties with new applications.

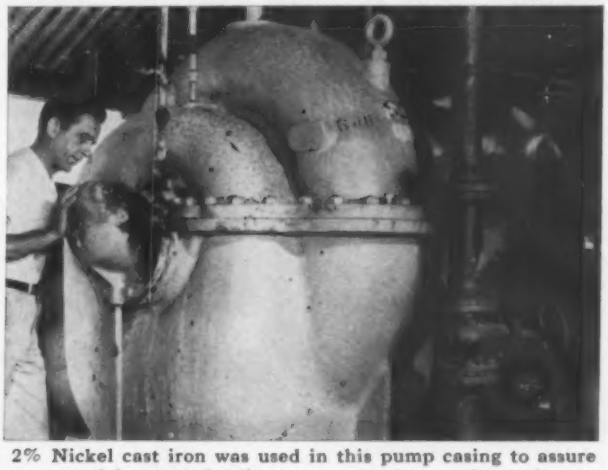
Severe damage to ladle refractories by molten steel has been greatly reduced at the Elektrostal Steel plant by using a graphite-fireclay brick lining. The brick is formulated of 45-55 per cent quartz sand, 20-30 per cent refractory clay, 10-15 per cent crystalline graphite, and 10-15 per cent ground ferrosilicon (75 per cent). Carbon pickup is not a serious problem but high thermal conductivity does accelerate metal cooling. An insulating firebrick layer next to ladle shell is advisable to slow temperature drop in metal.



This 1% Nickel cast iron mold has a dense, close-grained structure that assures highest-quality bottles and long service life.

Large, intricate castings made of 2½% Nickel cast iron have superior dimensional stability through light and heavy sections.

What every foundryman and user of castings should know about Nickel cast irons



2% Nickel cast iron was used in this pump casing to assure pressure-tightness and resistance to corrosion, erosion and wear.

Here are important facts about the combinations of properties available in Nickel cast irons . . .

1. Tensile and compressive strength

Nickel increases tensile strength, toughens and strengthens the matrix, and has a refining effect on the graphite in gray iron castings.

2. Wear resistance

Nickel cast irons have fine, uniform pearlite, and ideal graphite size and distribution that greatly improves wear resistance in castings.

3. Properties in varying section sizes

Nickel cast irons have ideal matrix structure and graphite distribution that tends to suppress chilling and promotes uniform properties throughout the casting. In unalloyed gray iron castings, hardness and strength are influenced by section size, because graphite flake size and matrix structure are dependent on cooling rates in castings.

4. Machinability over wide range of hardness

Nickel cast irons are *free* of hard carbides — have good graphite distribution and uniform matrix structure that promote best machinability at any given tensile strength.

5. Rigidity

Nickel cast irons have a higher modulus of elasticity than unalloyed gray irons, in conjunction with other enhanced properties.

6. Notch sensitivity and vibration damping capacity

Nickel cast irons have refined, uniformly-distributed graphite flake patterns that permit optimum damping capacity at any given tensile strength.

7. Resistance to thermal shock and general heat effects

From room temperature to approximately 650°F, Nickel cast irons withstand loads of approximately 80% of tensile strength for indefinite periods. And at temperatures to 1300°F, Nickel cast irons maintain a higher proportion of strength and hardness with less growth and scaling.

8. Response to heat treatment

Balanced alloy compositions of Nickel cast irons respond uniformly to hardening processes. Nickel lowers the critical temperature range of iron castings — assures a deeper, more uniform hardness with milder quenches that minimize cracking and distortion.

Superior combinations of properties

Superior *combinations* of useful engineering properties are possible with Nickel cast irons — including ready machinability, pressure-tightness and uniform properties in light and heavy sections. For engineering data on Nickel cast irons for specific applications, write to:

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street New York 5, N. Y.

INCO NICKEL

MAKES CASTINGS PERFORM BETTER LONGER

CORE MAKING METHOD									
BINDER	CHEM-REZ "100"	CHEM-REZ "100" with LINOIL	CHEM-REZ A-200	LIN-O-SET	LINOIL	ADCOSIL	ADMIREZ PHENOLIC	ADMIREZ PHENOLIC	ADMIREZ UREA
PROCESS	HOT BOX	OVEN BAKE	NO-BAKE	AIR SET	OVEN BAKE	CO_2	SHELL	OVEN BAKE	OVEN BAKE
CURING PRINCIPLE	Chemical & Heat	Chemical & Heat	Chemical	Catalytic Oxidation & Heat	Heat	Chemical	Heat	Heat	Heat
RANK in relation to:									
ACCURACY (core dimensions)	1	2	1	1	2	1	1	2	2
SPEED OF PRODUCTION (output per worker)	1	3	5	6	4	2	2	4	3
ECONOMY (Sand Mixture)	3	2	7	6	1	4	7	5	2
CONVENIENCE (Handling, Tooling or Precautions)	1	5	3	4	5	2	2	5	5
SIMPLICITY (Core quality Control)	2	1	5	6	1	4	3	1	1
VERSATILITY (Range of metals & core type)	2	2	4	4	1	5	3	3	4

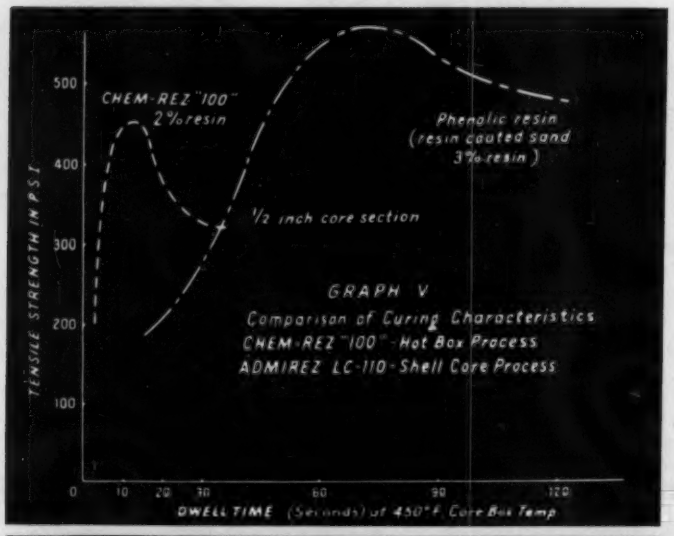
NOTE: Rankings given are in terms of "order of preference." No attempt is made in this comparison table to rate the various processes in terms of their relative value in each functional category

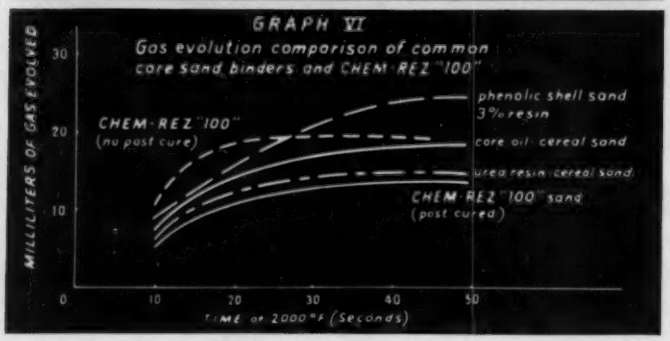
CHEM-REZ "100" RANKS FIRST in VALUE ANALYSIS of nine different types of ADM core binders!

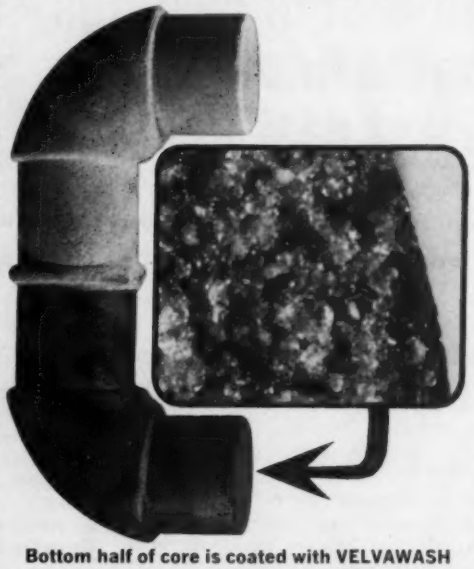
A comprehensive technical bulletin on CHEM-REZ "100" has been published by ADM to keep foundrymen up to date on the latest performance and application data. A copy is yours for the asking.

Graphs V and VI (below), taken from this 16-page bulletin, are typical of its contents. Other charts and tables cover: sand mixtures and cycles; core box temperatures; effect of resin and catalyst content; comparison of various types of catalysts; effect of core section thickness on tensile strength build-up; and comparative high temperature properties of CHEM-REZ and oil and cereal cores.

Also discussed is the application of CHEM-REZ "100" to various curing techniques such as: hot box; combined core oil and resin; oven baking — conventional, dielectric, infra-red, or re-dry. Write to ADM for your copy.







Bottom half of core is coated with VELVAWASH CR-100 . . . the wash that's MATCHED to CHEM-REZ "100" cores.

Twenty-power magnification above shows CHEM-REZ "100" hot box core coated with VELVAWASH CR-100. This wash clings tightly without penetrating so deeply that strength of the surface is deteriorated. Write for information.

Archer-Daniels-Midland

FEDERAL FOUNDRY SUPPLY DIVISION • 2191 West 110th Street • Cleveland 2, Ohio

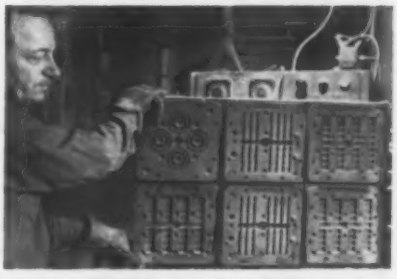
Circle No. 130, Pages 145-146

CRUCIBLE STEEL SAVES THIS MUCH RESIN PER 250-LB. DRUM

...by using high-quality MC shell-molding sand.

The unique physical characteristics and screen distribution of Pennsylvania Glass Sand's MC shell-molding sand enable Crucible Steel Company of America to reduce resin content by 25% and produce higher quality castings with better finish. This superior shell-molding sand comes from the PGS deposit at Mill Creek, Oklahoma—nearly 1,500 miles from Crucible's Harrison, N. J., plant. Nevertheless, Crucible's resin savings more than offset shipping costs from Oklahoma, while MC sand helps them produce castings of top-market quality.

Supersil silica flour and 35 grades of foundry sands are available from PGS to meet any casting requirement. For full details, contact your nearest PGS office.



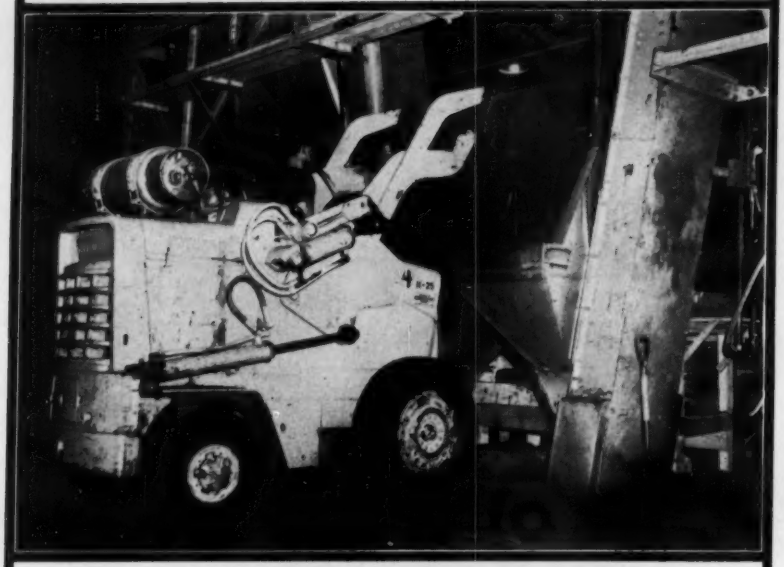
PENNSYLVANIA GLASS SAND CORPORATION

INDUSTRIAL SILICA DIVISION — PIONEER SILICA PRODUCTS CO.

Sales offices in New York, Pittsburgh, St. Louis and Dallas · **Plants** in Newport, N. J. · Mapleton, Pa. · McVeytown, Pa. · Utica, Pa. · Berkeley Springs, W. Va. · Dundee, Ohio · Geauga Lake, Ohio · Phalanx, Ohio · Klondike, Mo. · Pacific, Mo. · Mill Creek, Okla. · Brady, Texas.

Circle No. 132, Pages 145-146

Sand handling system built



around 3 PAYLOADER® units

Davis & Furber Machine Company of North Andover, Mass., specializes in manufacturing textile machinery. Since 1952 this company has been a continuous user of "PAYLOADER" tractor-shovels on its foundry floor. Two Model HA's (2,000-lb. operating capacity) handle sand, move materials, remove cupola waste and the like. Recently the firm added Hough's new H-25 (shown) to its "PAYLOADER" fleet. This unit is used principally during the molding operation, bringing sand from storage to supply a 4-station sand system. At night it returns the sand from the muller to storage.

You will find that an H-25 "PAYLOADER" tractor-shovel will pay for itself very quickly in savings alone —

OPERATING CAPACITY — Its 2,500-lb. capacity is 25% greater than has ever been available in a tractor-shovel of this size. Yet, it shuttles around corners, through narrow aisles, doorways and crowded yards, up and down ramps with speed and safety.

MECHANICAL FEATURES — The H-25 has a full reversing, power-shift transmission (no clutching) with two speed ranges forward and two in reverse, torque converter drive, power-steering (6-ft. turning radius), power-transfer differential and fast, powerful hydraulic bucket control.

A HOUGH DISTRIBUTOR is nearby to show you how the Model H-25 or a larger "PAYLOADER" (up to 12,000-lb. operating capacity) can increase output and lower costs on your bulk handling requirements. Contact him today or return the coupon below.

HOUGH®

THE FRANK G. HOUGH CO.
LIBERTYVILLE, ILLINOIS
SUBSIDIARY — INTERNATIONAL HARVESTER COMPANY

THE FRANK G. HOUGH CO.
711 Sunnyside Ave., Libertyville, Ill.

☐ Send H-25 "PAYLOADER" data
☐ Other "PAYLOADER" units to 12,000 lb. operating capacity

Name
Title
Company
Street
City State

11-A-2

Circle No. 133, Pages 145-146

From and For the Reader . . .

GRAPHITE FORM CLASSIFICATION

Reading C. K. Donoho's article "Ductile Iron Graphite Form Classification," in the July issue prompts this personal observation. Everything I have seen on the subject relates graphite form only to tensile strength, yield strength, and elongation. There are other properties, e.g., impact resistance, heat resistance, etc., which are probably subject to a more drastic influence by the presence of inferior forms of graphite than are tensile, yield, and elongation. They should not be excluded from consideration in any system of graphite classification.

K. D. MILLIS
Assistant to the Manager
International Nickel Co.
New York

PORTABLE HOPPER SYSTEM

I was impressed with the portable hopper system described in the July issue. Our iron foundry employs about 90 men but has no overhead sand facilities. I believe that this approach might be an ideal one for our needs.

I would appreciate any further details on the design and operation of the hopper system.

EDWARD R. SEEL
Chief Industrial Engineer
Howe Scale Co.
Rutland, Vt.

Editor's Note: Author W. D. Dunn is sending more details on the design and operation of the system.

DEFENDS THE WOMEN

Dietrich's Corner in the July issue, "Heaven Help Men—When Women Invade Foundry" rather floored me. I don't know whether this was written as a jocular insult to women workers in the foundry or whether it was meant to be a serious appraisal of women shop workers in a foundry.

Be it as it may, my experience with females in shop jobs during World War II and subsequently in peace times through the Korean episode and to date, has been that there are shop jobs that women workers

FIVE-DEEP

Unmatched facilities nearby

help you profit with UCM's "FIVE-DEEP" Ferroalloys

1 Unmatched Facilities for production and fast delivery of Union Carbide Metals' FIVE-DEEP alloys insure uninterrupted production at your metal-producing plant!

Six plants—3 with their own power facilities—and 17 warehouses, all located for fast shipments by rail, truck, or water.

These unmatched facilities are just one of the 5 intangible but ever-present extra values of FIVE-DEEP alloys. The others:

2 Strictest Quality Control — with over 100,000 tests per month from mines to shipment—makes sure you always get alloys of uniform size and analysis, with minimum fines, lot after lot.

3 Technology—many million dollars worth a year—helps you produce better, more profitable metals. UCM's 600-man research and development center is the birthplace of hundreds of new alloys.

4 Global Ore Sources assure you uninterrupted supplies of ferroalloys. UCM's close association with world-wide mines provides dependable raw material sources.

5 Customer Service brings you our integrated experience in the application of ferroalloys to various melting practices. Engineers from 9 UCM field offices travel a million miles a year to provide on-the-scene assistance.

For better metals, production economies, bigger profits, insist on UCM's FIVE-DEEP alloys. Union Carbide Metals Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y., producer of "Electromet" brand metallurgical products.

"Union Carbide" and "Electromet" are registered trade marks of Union Carbide Corporation.

UNION CARBIDE METALS

Only **ELECTROMET** ferroalloys from **UCM** are so deep in extra values to help you.

Circle No. 134, Pages 145-146

. . . WHAT HAPPENS TO YOUR CRUCIBLE?

Crucibles take more punishment than any other piece of equipment in your foundry. High temperatures subject them to internal stresses and strains. Caustic flux, fumes and oxide slags eat away at their surfaces. Molten metals thrust their weight against walls and bottoms, trying to bulge them out of shape.

Only the BEST crucibles can take this kind of treatment for long!

Many foundrymen say American STARRBIDE Crucibles are best because they can really take it . . . when the heat's on! This is because they are made of a special, carbon bonded material that gives them **greater strength** to resist the conditions which shorten crucible life. It is also the secret of STARRBIDE'S **exclusive thin wall** design which offers you these advantages . . .

STARRBIDE THIN WALL

STANDARD WALL

★ **More Metal Per Heat**

★ **More Heats Per Furnace Per Day**

★ **Less Fuel Per Pound of Metal**

★ **Lighter-Easier to Handle**

WHY NOT TRY A STARRBIDE CRUCIBLE?

Get the details from . . .

AMERICAN REFRACTORIES & CRUCIBLE CORPORATION

North Haven • Connecticut

Circle No. 135, Pages 145-146

are well qualified to do. We have been happy with the general experiences we have had. Of course there are some limitations by law on some of the jobs that women are not permitted to do.

However, the main problem for the general run of foundries, as it was originally with us, was the lack of proper locker facilities with showers, toilets, and restroom facilities. We constructed all such facilities for shop female employees.

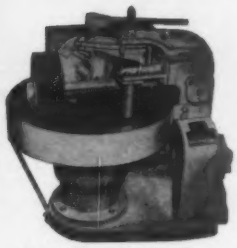
Our experience beginning in World War II was that there were three types of women shop workers. It was quite a screening problem for our personnel and employment department to make proper selections.

The first type female workers were the "working" women who were accustomed to work. The second type were the "patriotic" women who were entering into the manufacturing world for the first time, but were doing so because of the contribution they might make to the war effort. The third type was the "romantic" women and thank heavens' they were comparatively few who were interested in "romancing" which wasn't conducive to the work atmosphere of a foundry. They were disposed of rather promptly when the label was pinned on them.

Under the Ohio laws, female employees are restricted lifting repeatedly weights exceeding 25 pounds. They might have been somewhat limited in the work they did in casting inspection and in core finishing and assembling. But there was sufficient work of the character they are permitted by law to do and which they were quite willing to do. Fortunately we had no problems with the male workers who worked in the same job categories because they had to lift the heavier loads which the women were not permitted to lift.

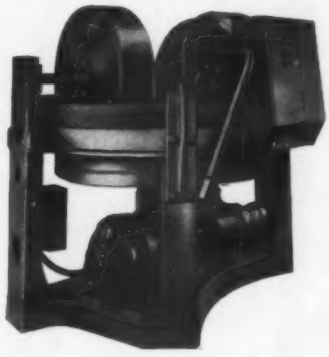
It was at the beginning of World War II that the foundry time-keepers were well qualified female employees who wore coveralls, a matching cap and steel-toed safety shoes. As a matter of fact, time-keepers were the original female employees in the shop followed by coremakers, core finishers, core assemblers, testing sorters and inspectors, laboratory personnel and the like. About 10 per cent of our employees at the end of World War II were female employees.

I would like to go on record as saying that the job of female employees in the shop was a tremendous contribution to the war pro-

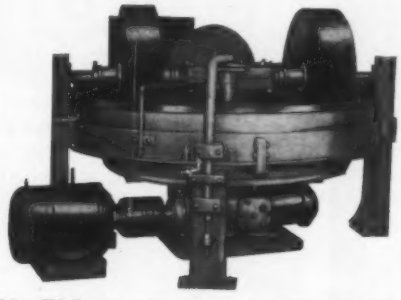


No. 251 2½-ft. diameter
. . . . ½ to 1 cu. ft. batch

No. 414 4-ft. diameter
. . . . . 2 to 4 cu. ft. batch



No. 610 6-ft. diameter. . . . 10 to 14 cu. ft. batch



No. 715 7-ft. diameter. . . . 15 to 20 cu. ft. batch

No. 930 9-ft. diameter. . . . 30 to 40 cu. ft. batch

ANY SIZE MADE TO YOUR SPECIFICATIONS

From compact portables to heavy-duty mullers

CLEARFIELD CAN SUPPLY THE RIGHT MIXER FOR YOUR JOB

Clearfield Mixers are available in capacities ranging from ½ to 40 cu. ft. . . . for batch or continuous mixing. They're constructed of rugged cast iron for strength, rigidity and wear resistance. And all Clearfield mixers feature the "revolving pan" mixing principle which keeps the material in *constant* state of violent motion; this eliminates the "lag" intervals which result in mixers with mullers and scrapers that revolve instead of the pan. With Clearfield revolving-pan mixers you get a constant controlled-course mixing action which assures a better balance of blending and tempering.

Whether you need a mixer for maintaining proper bond and moisture in heap sands . . . preparing facing sand or core sand for castings . . . or for any foundry application where sand control is important . . . Clearfield Mixers can do the job better, and save you production money.

Let us help you determine the best type and size for your particular needs. No obligation. Meanwhile, send for Catalog No. 90.

CLEARFIELD
MACHINE COMPANY
CLEARFIELD
PENNSYLVANIA, U.S.A.

Circle No. 136, Pages 145-146

TESTED by use and PROVEN!

by hundreds of American Foundries and other abrasive users.

EXPENDABLE PALLET PACK

Forty 50 lb. cartons in one master pack: easy to store, easy to inventory, easy and safe to handle. No extra Cost. Also in conventional 100 lb. or 50 lb. bags.

There is no better shot and grit than that distributed by Hickman, Williams & Company: NEW CONTROLLED "T"; PERMA-STEEL; PERMA-BRASIVE. All five have been, for many years, the first choice of the largest users of abrasives. We can meet your specifications and, at the same time, reduce your costs.

It costs you nothing to get the Real Facts about ABRASIVES.

70 Years of Service to American Foundrymen

Hickman, Williams & Company

CHICAGO • DETROIT • CINCINNATI • ST. LOUIS • NEW YORK
CLEVELAND • PHILADELPHIA • PITTSBURGH • INDIANAPOLIS • ATLANTA
Established 1890

Circle No. 137, Pages 145-146

duction effort and they were helpful in meriting for this company, an Army-Navy E with four stars.

We at Hamilton Foundry have had and still have great respect and regard for properly selected "working" women in the foundry, which is the reason I am writing because I can't understand any justification for the article.

PETER E. RENTSCHLER
President
Hamilton Foundry Inc.
Hamilton, Ohio

Editor's Note: In the August issue Mr. Dietrich presents the other side of the story—the good qualities of women foundry workers. He swears that he too has high regard for the ladies.

PYROMETER SHEATHS

We are interested in your item in the July issue on the use in Czechoslovakia of molybdenum alumina cermet pryometer sheaths.

We have been producing molybdenum alumina sheaths for about four years. Recently the rate of manufacturing has increased and these pyrometer sheaths are now used extensively in England and in Europe.

These sheaths have proved to be extremely good in vacuum melting furnaces and where conditions are severe, but they are not yet replacing quartz tubes for general work. Your article refers to quartz tubes being expensive, but naturally they are cheaper than a molybdenum-alumina cermet. In fact, our sheaths are around forty times those of quartz tubes.

D. W. BROWN
Products Research
Morganite Research & Development, Ltd.
London, England

INCORRECT LISTING

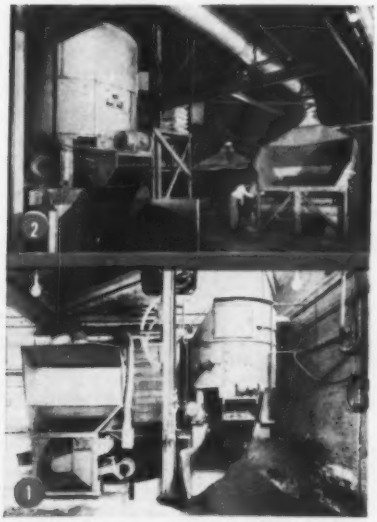
Our company was incorrectly listed as a contributor to your market opportunities story "Die Cast Zinc Meets Competitive Demands" in the August issue. The correct corporate name is The Electric Autolite Company, Die Casting Division.

FRED A. PRATT
Division Sales Manager
Woodstock, Ill.

Editor's Note: We appreciate your calling our attention to this typographical error. In the haste of going to press with this last minute story we goofed.

MECHANI-MIZE*
FOUNDRY-WISE
WITH
NATIONAL
UTILITY UNIT
*Meaning . . . now it's easy and economical to get your sand up off the floor without major plant changes or big equipment costs.
3

Planned, Progressive Mechanization grows with you . . . costs you less



2 *Here's a start.* Mix-Muller, Loader, Screen-Master and exhausted hopper. Note magnetic separator.
2 *A step further.* Heavy duty shakeout screen is added.
2 *Next step . . .* elevator replaces loader and conveying equipment is added—still without major plant change or extensive pit or overhead work.

Here's an expandable sand conditioning and handling unit designed to increase your output at welcome savings in time and labor . . . without major expansion, plant change or big investment in mechanization.

If you have a Mix-Muller, you have a start! The simple addition of a National Screen-Master, Bucket Loader and Aerator can turn your mixing operation into a conditioning plant. A front end loader will get your sand up off the floor. As your mechanization needs grow, you'll find that National has the equipment and the know-how to help you grow efficiently, economically—to a predetermined Foundry-wise plan.

Why not let your NATIONAL representative show you, by your own records, how a National Utility Unit can pay its own way in as little as two years time?

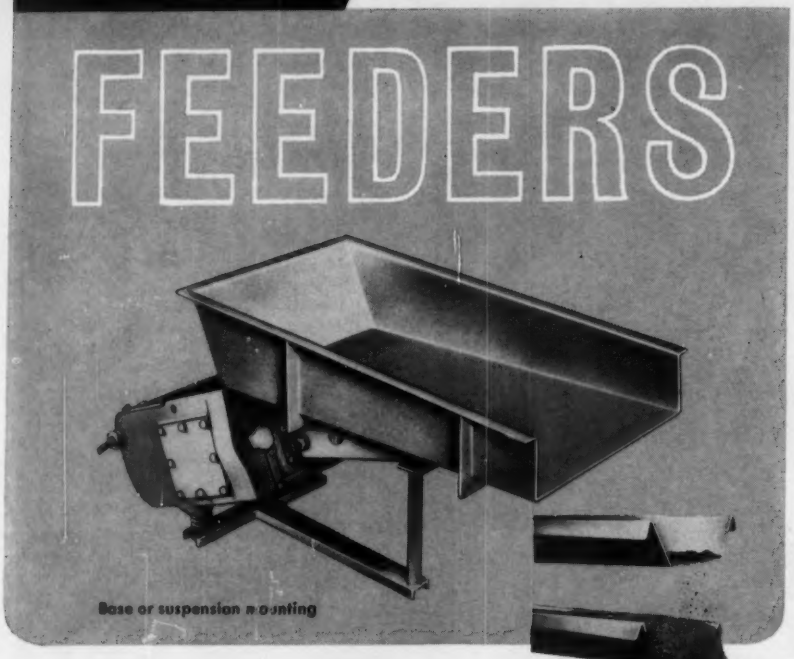
WRITE FOR LITERATURE

NATIONAL ENGINEERING COMPANY
630 Machinery Hall Bldg.
Chicago 6, Illinois

F460

HANDLE BULK MATERIALS AT LOWER COSTS

SYNTRON VIBRATORY FEEDERS



Base or suspension mounting

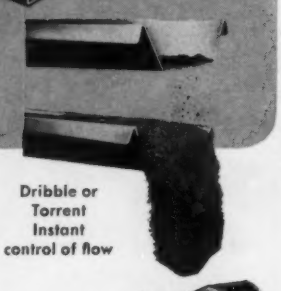
Dribble or Torrent Instant control of flow

Move bulk materials at constant, dependable, instantly controlled rates

Syntron Vibratory Feeders provide the most efficient and economical method of conveying bulk materials. They have proven for more than 30 years their ability to handle most types of bulk materials—fine powder to large lumps—hot or cold—dry or damp—in densities from 400 pounds to 6 pounds per cubic foot.

The simple electromagnetic drive unit produces 3600 vibrations per minute, assures continuous, dependable operation with a minimum of maintenance. The finger-tip control of material flow enables Syntron Vibratory Feeders to effectively fill the production gap between storage and process operation.

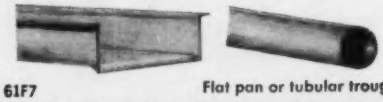
Syntron Vibratory Feeders are available in wide range of feed capacities, with above or below deck magnets, flat pan or tubular troughs, base or suspension mounting. Syntron Vibratory Feeders are the answer to lower bulk materials handling costs.



Above or below deck magnet

Manual or Automatic Control

Write for detailed literature today.



61F7

Flat pan or tubular trough

SYNTRON COMPANY
545 Lexington Ave. • Homer City, Pa.

Other Syntron equipment of proven dependable quality

Lapping Machines

Vibrating Screens

Circle No. 139

Mechanical Vibrating Conveyors

New Books...

Contemporary Russian Metallurgy Problems

Contemporary Problems of Metallurgy . . . A. M. Samarin. Translated from Russian. 530 pages. A study of Russian problems. Published by the U.S.S.R. Academy of Science Press, it consists of six sections; metallurgical raw-material and fuel base of the U.S.S.R., metallurgy of iron and steel, metallurgy of non-ferrous metals, working of metal by pressure, science of metals, and general problems of metallurgy. Among articles of interest of foundrymen are "The Nature of Strengthening of Magnesium Alloys of the System Mg-Mn-Al-Ca at Elevated Temperatures," "The Nature of Martensitic Transformations," "The Structural Theory of Creep in Metals," and "Raising the Strength and Toughness of Low-Carbon Steel by Heat Treatment."

Guide Books for Better Industrial Management

Industrial Management Guide Book Series . . . B. T. Lewis and W. W. Pearson. A series dealing with vital areas of management responsibility. Included are guides for maintenance supervisors, production control, preventive maintenance, applied industrial psychology, work simplification, human relations in industry, maintenance cost reduction, industrial supervisors, effective communications, and personnel directors. The set will be completed with guides for industrial training directors, research laboratory supervisors, interviewing and conference techniques, and statistical quality control.

Metallurgical Dictionary in French and English

Dictionnaire De Metallurgie . . . Par O. Bader and Et M. Theret. 702 pages. An illustrated French and English metallurgical dictionary. A metallurgist and a foundryman have compiled in one volume a group of terms and description of processes, chosen according to their frequency of use in metallurgy generally and in the foundry in particular.

An alphabetical classification has been adopted. When deemed neces-

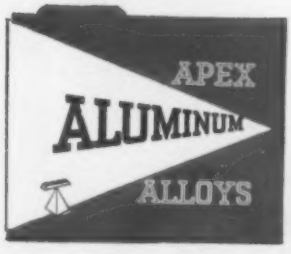
APEX ALLCAST 70

An Aluminum Alloy that assures consistent high quality with economy

A general-purpose aluminum alloy, Allcast 70 offers superior mechanical properties as well as worthwhile savings through higher yields.

Pressure tightness, high fluidity with absence of shrinkage are assured by rigid technical control of all steps in its production.

Allcast 70 has delivered uniform performance in millions of pounds of sand and permanent mold castings produced over the past 15 years. Superior products such as Allcast 70 are a specialty of Apex . . . a name foundries know they can rely on every time.



Send for our brochure, "Apex Aluminum Alloy," which lists composition, mechanical properties and heat treatments of standard Apex products. No obligation.

Research leadership back of every ingot

Warehouse distributor of ALCAN foundry alloy ingot

APEX SMELTING COMPANY

CHICAGO 12 • CLEVELAND 5 • LONG BEACH 10, CAL.
SPRINGFIELD, OREGON (NATIONAL METALLURGICAL CORP.)

Circle No. 140, Pages 145-146

Th-Mg: ONE REASON WHY VITRO'S RARE EARTH CHEMICAL / METAL ALLOY SALES ROSE 34% IN 1960.

There must be good reasons for this growth. And there are—consistent high quality backed by research. Perhaps Vitro's product development department can assist you. Do you have production difficulties adding alloy components or face burn-up problems where the use of master alloys can be effective? Vitro quality control provides guaranteed uniformity and offers end-product consistency. ■ In addition to thorium-magnesium master alloy, Vitro has developed several rare earth and related family alloy combinations. Its technical staff is anxious to join with you in formulating new alloy combinations and special custom blends. They also can supply pure metals of the rare earth family. Write today for complete technical literature and please feel free to discuss any specific research or production problem without any obligation. Address Product Development Department G.

Vitro's thorium-magnesium master alloy is extensively used in our nation's expanding missile effort. Some 40% of the "skin" on the USAF Titan missile is thorium-magnesium alloy.

Vitro CHEMICAL COMPANY
a Division of Vitro Corporation of America
261 MADISON AVE. • NEW YORK 16, NEW YORK
Circle No. 141, Pages 145-146

sary, curves, diagrams, tables, and micrographs have been used. For each French term, the English equivalent has been indexed. The index contains English words in alphabetical order with the French translation which permits one to be acquainted with a detailed definition of the terms.

A.S.T.M. Copper Standards

Compilation of A.S.T.M. Standards on Copper and Copper Alloys-B-5, American Society for Testing Materials, 746 pages. Contains 134 standards of which 37 are new, revised, or have status changed since 1959.

Also contains material on selected specifications on non-ferrous metals and alloys for primary forms of copper, zinc, lead, and nickel used in copper-alloy products.

Importance of Oxygen in Electric Steelmaking

The Use of Oxygen in the Electrometallurgy of Steel . . . G. M. Borodulin. Translated from Russian. Stresses the importance of oxygen in electric steel melting practice. Use of oxygen is examined in the electro-melting of stainless, transformer, cracking, high-speed, chromium nickel structure, ballbearing, and high-carbon tool steel. The productivity of electric furnaces has considerably increased in this connection, the cost of steel decreased, its quality has improved, and in certain steels rejects have been completely eliminated.

Temperature Measuring Book Emphasizes Applications

Temperature Measurement in Engineering, Vol. II . . . H. Dean Baker, E. A. Ryder, and N. H. Baker. 510 pages. Presents how-to-do-it directions for the measurement of temperatures in laboratory, shop and field. The first section is devoted to a discussion and systematic development of the basic methods, resistance-thermometry and radiation-pyrometry techniques, on an engineering-design-technique basis. Special techniques are described in terms of the greatest adaptability they may possess, but mainly in conjunction with the specific problems for which they offer solutions. The second part offers a detailed treatment of specific problems of temperature measurement, organized by situations and techniques most suitable for solution.

Computer Analyses Now Make Tenzaloy Better Than Ever

TENZALOY

Asarco has introduced another significant advance in aluminum casting alloy technology — computer correlation of composition and properties of its widely used high-strength, self-aging Tenzaloy. Results: Further refinement in quality and reliable performance of this superior alloy.

Data for the pioneering computer analyses were drawn from a long record of properties and composition of Tenzaloy plant heats compiled by Asarco's Central Research Laboratories. From these studies has come new knowledge of the interaction of Tenzaloy elements and effects of alloying ingredients on mechanical properties.

Computer findings now enable Asarco metallurgists to control Tenzaloy mechanical properties to a much narrower range of variation and to higher average values than ever before — and to reproduce them precisely and consistently over and over. There is only one Tenzaloy and it cannot be duplicated.

TYPICAL PROPERTIES OF TENZALOY

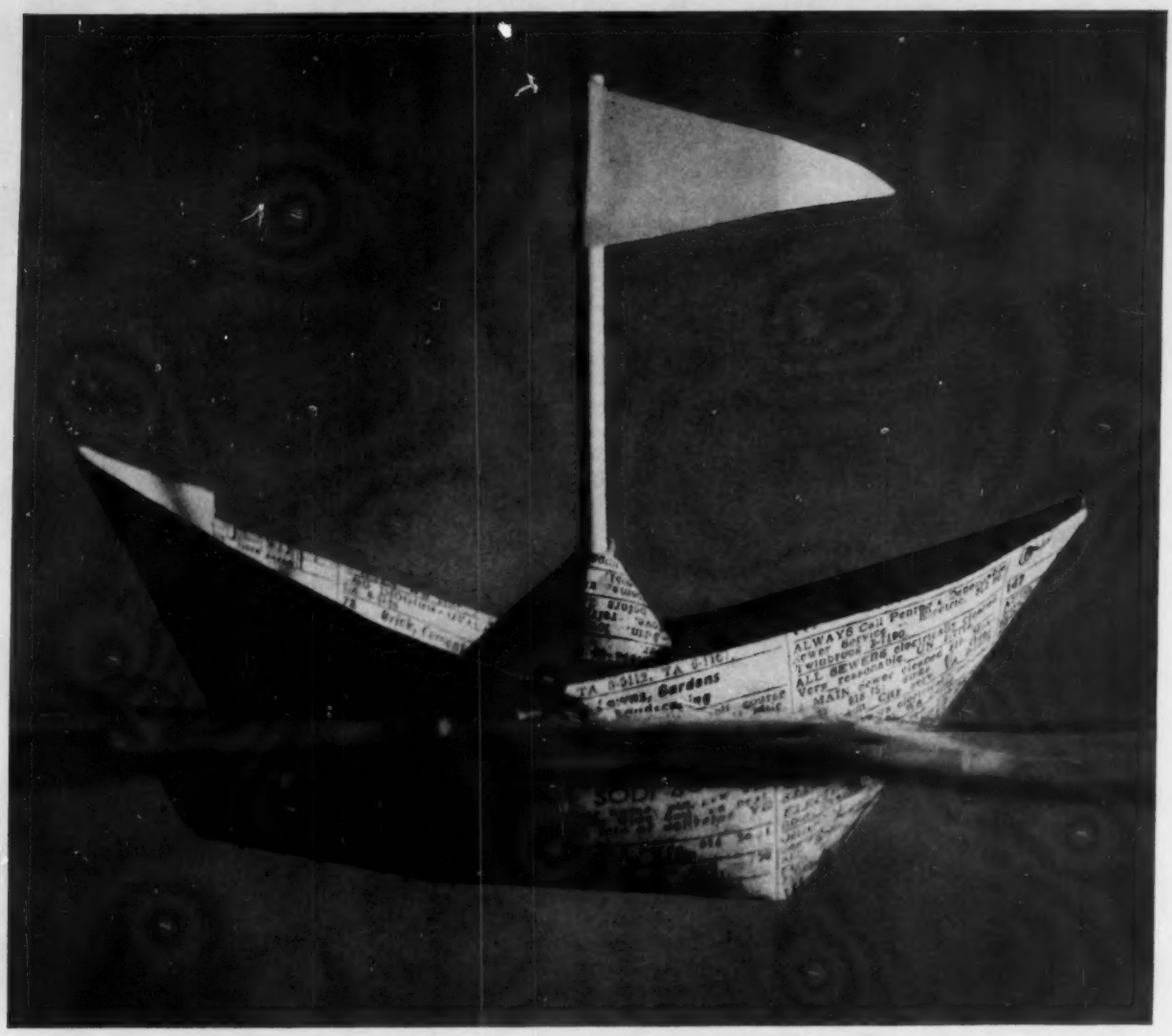
	SAND CASTINGS	PERMANENT MOLD CASTINGS
Tensile Strength	35,000 psi	40,000 psi
Yield Strength	25,000 psi	27,000 psi
Elongation (in 2")	4-5%	6-7%
Brinell Hardness No.	74	74
Impact Strength (Charpy in ft./lbs.):		
Notched	3	3
Un-notched	14	20
Electrical Conductivity	30%	30%

Tenzaloy can widen design horizons, increase production efficiency, reduce costs and improve your products. For your copy of Bulletin 103R5, "Tenzaloy, the Self-Aging Aluminum Casting Alloy," write today to: Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N. Y.

ASARCO

Burroughs B205 computer correlates unique composition and properties of Asarco's high-strength Tenzaloy.

How the Foundry Industry Serves America . . . #19 of a Series



SHOULD A MATERIAL BE LIGHT OR RIGHT?

Is there a simple solution to the problem of reducing weight? Well, there is one that *sounds* simple. Why not use lighter materials? That's what we did with the toy boat in the picture.

It's the lightest thing afloat. But lightness alone isn't quite enough, is it? Because the paper will get soggy and the boat will sink. Of course, we could process the paper and waterproof it. But why not save added expense and complexities by sticking to a material that's *naturally* suited to boat hulls?

Castings, too, can be made with lighter materials. But even complicated, costly "toughening up" processing won't give some lightweight metals the wear resistance, heat resistance, dampening qualities, strength, stability and machinability of reliable iron castings.

So why not stick with the proven material that's *naturally* suited to so many applications? Design engineers, together with their colleagues in the iron foundry industry, have already found many ways to lighten iron castings through improved design. This way they are achieving new weight reductions, economically and safely.

HANNA
THE BEST KNOWN NAME IN IRON

THE HANNA FURNACE CORPORATION
Suppliers of quality pig iron to the American Foundry Industry
Boston • Buffalo • Chicago • Detroit • New York • Philadelphia
Hanna Furnace is a division of
NATIONAL STEEL CORPORATION

Circle No. 143, Pages 145-146

In the interest of the American foundry industry, this ad (see opposite page) will also appear in

D.A.C. NEWS
STEEL
IRON AGE
FOUNDRY
AMERICAN METAL MARKET
GRAY IRON NEWS

FREE!

REPRINTS OF THIS AD WITH YOUR FIRM'S SIGNATURE

If you would like to have reprints of this ad to mail to your customers and prospects, let us know. Reprints will have no Hanna product message or signature, but will be imprinted with your firm name and address. Absolutely no obligation. To order your reprints, fill in and mail the coupon below.

The Hanna Furnace Corporation
Detroit 29, Michigan

Please send me_____reprints of Ad No. (No.)

_____of your Foundry Industry Series.

Imprint as follows:

_____

_____

_____

Send reprints to:

NAME_____

I understand there is no charge for this service.

If It Moves, Salute It! If You Can't Pick It Up, Paint It!

BY HERBERT J. WEBER

Many of us have heard this advice facetiously given to the young sailor coming out of boot camp. Come to think of it, it's pretty good advice especially regarding painting. That's why our "men-o-war" look so tidy and shipshape.

But why not use a little color dynamics in a foundry? Foolish? Well just ask the people at Massillon Steel Castings Co. They'll tell you how they eliminated a bottleneck in the cleaning room—not by hiring morme people or installing more equipment but by, believe it or not, painting it.

I could tell you about other foundries that cleaned up and painted up. You wouldn't throw even a cigarette butt on the floor if the floors are clean. But when a place is littered with rubbish, what difference does a little more make?

Do you know that if you coat all your steel columns, beams and duct work with aluminum paint, they will radiate one third as much heat as the bare steel and improve light reflection considerably? You get less heat, more light and improved appearance for a coat of aluminum paint.

Color has been an increasingly important factor in plant safety for many years. Many instances are on record where the accident rate has been lowered through color identification of danger points.

Injuries Are Reduced

A decrease in personal injuries as great as 40 per cent followed the use of a uniform color program. These results are realized because of greater visibility and positive identification standards.

When dangerous parts and objects are marked with attention-getting colors; when aisles are outlined with zone marking lines; when dark passageways are made lighter with light-reflecting colors, the safety index of the plant rises notably.

The basic colors recommended by the American Standards Association Color Code are eight in all—red, orange, yellow, green, blue, purple, black and white. They are used as follows:

Red—(1) Fire protection equipment, (2) Danger, (3) Stop.

Orange—(1) Dangerous parts of machines which may cut, crush, shock or otherwise cause injury.

Yellow—(1) Designating caution, (2) Marking physical hazards such as striking against, stumbling, falling, tripping and "caught in between."

Green—(1) Designating safety, (2) Location of First Aid equipment.

Blue—The basic color for caution against starting equipment that may be under repair.

Purple—The basic color for radiation hazards.

Black and white—The basic colors for housekeeping and traffic markings.

Color Dynamics

The use of colors for the application designated is called color dynamics—the power of color. I believe that's a very good term because I know the powerful effect color painting has had on workmen.

It resulted in less absenteeism; men practiced better housekeeping; even sloppy workmen corrected their bad habits; and the boss was never ashamed to have customers in the plant.

Customers are impressed by a clean plant and are inclined to have more confidence in the product. It's hard for anyone to imagine how a good product can come out of a dingy, sloppy plant.

At first glance, painting a foundry seems futile. But if the work is done one department at a time, the task doesn't seem insurmountable.

"If you can't pick it up, paint it!" is a good motto after all.

For Customer Satisfaction

Barker Foundry Supply Provides Best Products, Prompt Delivery

Reliable service and the best foundry bentonites equal better castings and happy customers. This formula underlies every phase of operation of Barker Foundry Supply, distributor of Magcobar YELLOWSTONE, AUTOBOND, and SOUTHERN STAR foundry bentonites in Southern California, Arizona, and Southern Nevada. It's one of the reasons why Barker has become an outstanding success as a foundry supplier. Three other reasons are these unusually competent Barker personnel.

Bruce Farrow, a veteran of the foundry supply business, has served as President of Barker for eight years. During that time, the concern has shown a steady increase in sales and growth. He was graduated from U.C.L.A. in 1937 with a B.A. degree in Economics.

Charles Tingler, Co-owner and Vice-president, has over 13 years experience in foundry operations and over 14 years in foundry supply sales. He has been a member of the American Foundrymen's Society for 20 years. He was born in Moreland, Oklahoma.

Christy Della Rocca, Sales Engineer, served in various foundry production capacities for 18 years, topped that with another 13 years as a salesman and an inspector connected with foundries prior to joining Barker. From this experience has come his motto, which is to "give 100 percent attention to customers' problems, large or small."

These men of Barker are typical of the high-caliber Magcobar representatives located in foundry centers of the United States. So, for better castings, at lower costs, contact your local Magcobar dealer. He is ready and able to serve as a member of your castings production team.

Magnet Cove Barium Corporation

P. O. Box 355, Arlington Heights, Illinois

P. O. Box 6504, Houston, Texas

Circle No. 144, Pages 145-146

TRENDS IN EDUCATION

What Next for Apprenticeship Training in Metalcasting?

By R. E. BETTERLEY

The above question bothers me. And, I'm sure it concerns you, too. Perhaps this dissertation will seek more information from you than contribute any startling proposals for change. If such is the case, your ideas on the subject are welcomed.

In the metal castings industry, three main occupations stand out as requiring high skills and apprenticeship as a normal means of entry. These are: *Molding, coremaking* and *patternmaking*. Apprenticeship standards have been based on a four to five year program—four years for coremakers and molders and five years for patternmakers. These programs are controlled and set up by local and federal joint apprenticeship committees as agencies representing education, labor and management. The U. S. Department of Labor's Bureau of Apprenticeship and Training (BAT) assists industry and local groups in the development and improvement of these programs. In this work, the BAT is guided by a Federal Committee on Apprenticeship.

To me, a single and accurate answer to our question is not foreseeable for the industry as a whole. The training needs and personnel requirements vary considerably among foundries. Type of operation, size, production requirements, metals cast, and geographic location are variables which add to the problem. In some instances, a foundry may not be able to utilize a standardized formal four-year apprentice program. It may have little interest in, for example, a four-year journeyman molder. Why is this? Even though some flexibility can be built into local indentured four or five-year programs to meet individual foundry requirements, it is logical to assume that many foundries may be more interested in the short-period intensive training of a machine operator. They may only want trainees as jolt-squeeze or molding machine operators. At this time, it may be expedient to satisfy production requirements.

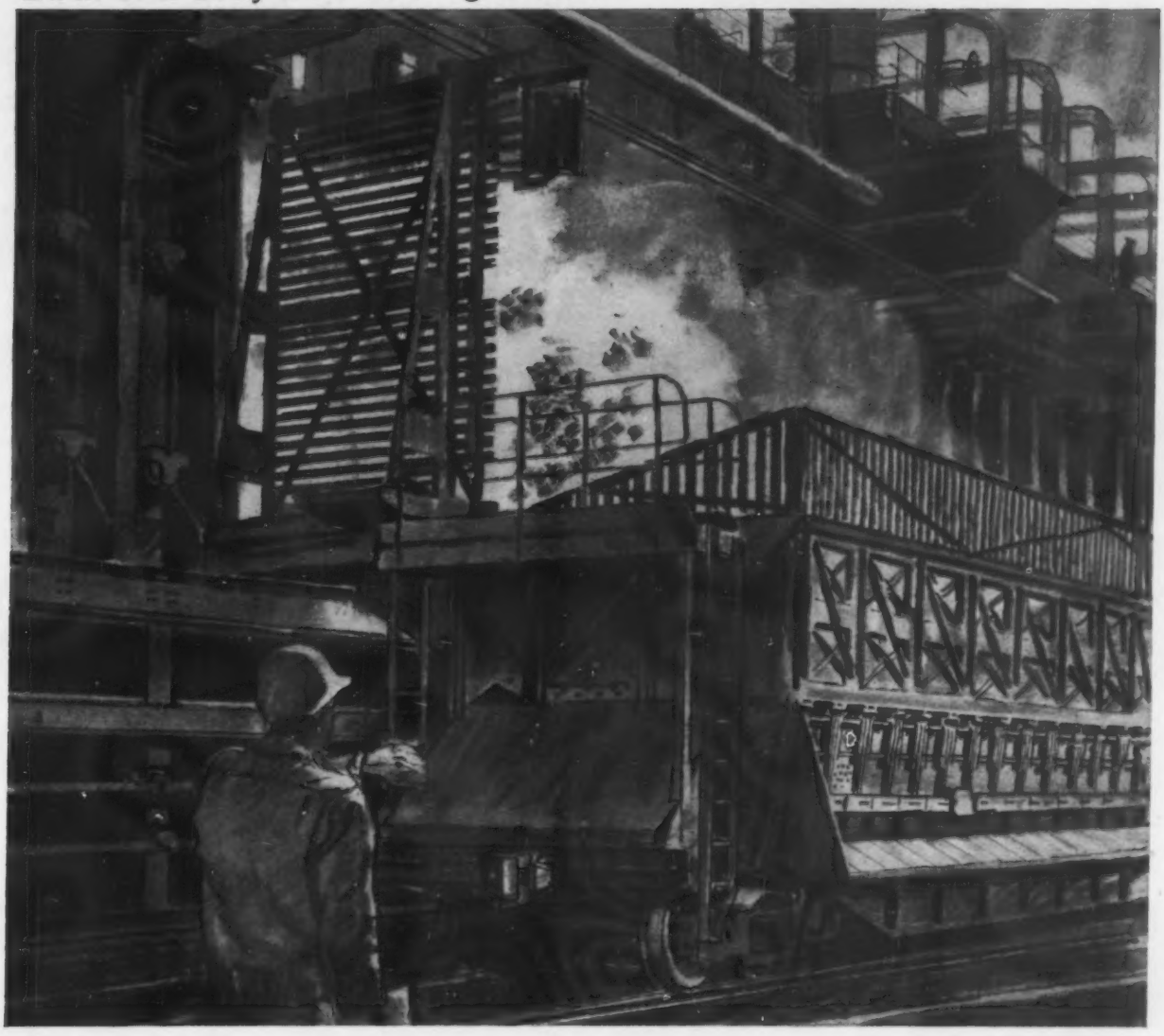
However, my question now is: To what extent do experienced journeymen have to assist such "molders?" A steel foundryman recently told me that difficult jobs and assistance to machine molders were the responsibilities of three key men who had *85 years of combined molding experience.* What happens when this experience leaves the industry? Who solves the tough molding problems then?

The apprenticeship problem is more acute in the occupations of coremakers and molders. According to statistics from the U. S. Department of Labor, BAT, the number of registered apprentices in these crafts dropped from 1081 in 1953 to 637 in 1960. This represents a drop of about 42 per cent. In patternmaking for the same period, there has been an increase of over 27 per cent, with 894 apprentices registered at the end of 1960. This trend parallels registration in the AFS Annual Apprentice Contest, where patternmaking entrants consistently outnumber molding entries.

It seems to me foundries, regardless of mechanization and specialization, must see beyond their immediate selfish needs. Through proper training now, they must share the responsibility of providing the necessary experienced personnel for the years ahead.

Foundry management and trainers should be active in discussing and solving these basic problems. Multi-state and state apprenticeship conferences are held annually and biennially where leading representatives from labor, management, and education lead the discussion. Trade groups, such as foundry and patternmaking, have special sessions at these conferences. In the Midwest, for example, the 2nd Biennial North Central States Apprenticeship and Training Conference will be held Oct. 26-27, in Chicago. Other conferences are scheduled throughout the U. S. Registration and program details on conferences can be secured from all BAT offices. (BAT, 105 W. Adams St., Chicago 3, Ill.) This is a fine opportunity for foundrymen to seek the answer to our title question.

Birth of a Gray Iron Casting—No. 4



PRODUCTION OF FOUNDRY COKE

A 15-ton slab of fiery, red hot coke, crumbling and cascading into a quenching car is one of industry's most spectacular events. The coke push is one of the final steps in coke production . . . a process that works with ton-weights, yet demands the precision control normally associated with metric ounces.

In Neville Foundry Coke production carefully selected coals containing a high percentage of Pocahontas, are washed, blended and transported by conveyor belts to storage bins above the coke ovens.

Each charge is weighed so that approximately 18 tons of blended coals are placed into each oven. All openings are then sealed and the blend is "coked" under closely controlled conditions for an exact period of time. A fifty-foot ram pushes the fired coke from the oven into quenching cars. The cars are then moved under the quenching tower where 10,000 gallons of water are sprayed onto the coke to prevent it from consuming itself. Sizing and grading are the final steps in the production process.

The end result is Neville Foundry Coke—a hard, dense product, high in carbon content, low in ash and sulphur . . . "tailor-made" for the production of high quality gray iron castings.

COKE & IRON DIVISION
PITTSBURGH
COKE & CHEMICAL CO.
GRANT BUILDING PITTSBURGH 19, PA.

Neville Pig Iron and Neville Coke for the Foundry Trade

Circle No. 145, Pages 145-146

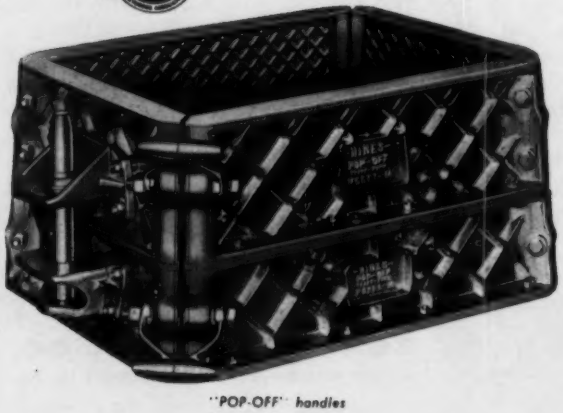
HOLD 'EM DOWN!

MOLDING COSTS

It's an established fact that you need good equipment to turn out good molds — economically. And there's no other type of foundry equipment you might invest in that will pay bigger dividends than HINES "POP-OFF" flasks. These exceptionally efficient flasks will hold your molding costs to a minimum by producing an unusually high percentage of perfect molds and, conversely, less scrap.

Fixture-built to extreme accuracy, reinforced at the parting line and buttressed with the familiar diagonal ribs, HINES "POP-OFF" flasks are built to outperform and outlast any other flask on the market. They last longer, too, because hammering isn't necessary for removal — just move the "POP-OFF" levers and off they come!

HINES POP-OFF FLASK FEMA



"POP-OFF" handles in "open" position

Made in standard, medium and heavy-duty weights, sizes to 36" by 48". Trunnions, handles, reinforcing pipe, pin arrangement to your requirements. If you want the best, the most economical flasks on the market — get in touch with us for our recommendation.

THE HINES FLASK CO.

3433 WEST 140th STREET • CLEVELAND 11, OHIO

ORchard 1-2806

"POP-OFF"—®

HINES FLASKS

Circle No. 146, Pages 145-146

Crouse-Hinds reports on Shalco Shell Core Blowing:

3 Shalcos Plus 1 Operator Produce 7,000 Cores In 7½ Hours!

Production as high as 7,000 top quality cores in one 7½ hour shift is the big reason Crouse-Hinds Co. of Syracuse, N.Y., is sold on Shalco Shell Core Blowing. C. H. Alvord, New Process Engineer, explains: "We decided to try shell cores because we need extremely smooth surfaces on the inside of our electrical fittings and are always looking for ways to reduce production costs. After an extensive study of *all* shell core machines, we bought a Shalco U-180 and, because of its excellent performance, soon installed three more identical machines. With our present arrangement, three of the Shalcos are operated by one man while the fourth is being set up for the next job. With the Shalcos we can produce a wide variety of cores including those shown at right; sometimes need *three* inspectors to handle and pack production output of the *one* core machine operator!"

Efficiencies such as those described by Mr. Alvord are commonplace among Shalco users. It will pay *you* to get complete information. Call, write or wire . . . today.

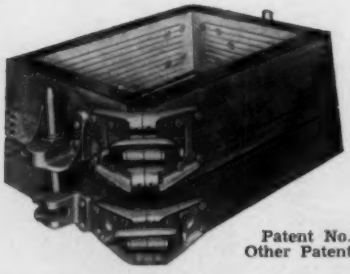
Shalco Division of
National Acme

THE NATIONAL ACME COMPANY
173 E. 131ST STREET
CLEVELAND 8, OHIO

Sales Offices: Newark 2, N. J., Chicago 6, Ill., Detroit 27, Mich.
Licensee in the United Kingdom: Stone-Wallwork, Limited, London SW-1, England

Circle No. 147, Pages 145-146

LARGE OR SMALL



Patent No. 2393200
Other Patents Pending

ADAMS CHERRY
EASY-OFF FLASK

PIN AND EAR ARRANGEMENT SUPPLIED TO SUIT YOUR PRESENT PATTERN PLATE GUIDES

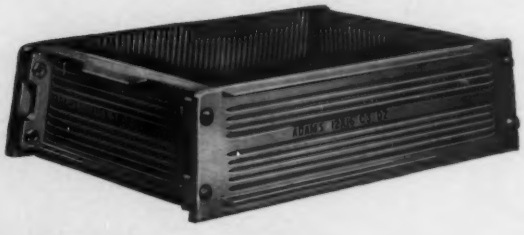
Write us today for our circulars on Cherry Easy-Off Flasks and Cast Iron or Aluminum Jackets.

ADAMS CHERRY EASY-OFF FLASKS

with ADAMS JACKETS

CAST IRON OR ALUMINUM

To Complete
a winning combination



The ADAMS Company

700 FOSTER STREET, DUBUQUE, IOWA, U. S. A.

MOLDING MACHINES
and
FLASK EQUIPMENT

ESTABLISHED
1883

Circle No. 148, Pages 145-146

YOUR KEY to Better, Cleaner Brass Castings...

Famous CORNELL
BRONZE & BRASS FLUX

- Cleanses molten brass whether red or yellow even when the dirtiest brass turnings or sweepings are used.
- Longer crucible life — no metal loss.
- Forms a perfect covering over the metal during melting, prevents oxidation and reduces obnoxious gases to a great extent.
- Write or call for full information.

The CLEVELAND FLUX Company

1026-40 MAIN AVENUE, N.W. • CLEVELAND 13, OHIO

Manufacturers of Iron, Semi-Steel, Malleable, Brass, Bronze, Aluminum and Ladle Fluxes . . . Since 1918

FAMOUS CORNELL FLUXES

Circle No. 149, Pages 145-146

AFS Board Gives T&RI Expansion Green Light

Tax ruling and directors' decision give new impetus to Institute plans. Research, technical field training, Foundry Instructors Seminars, scholarships, and construction of training center in Des Plaines are immediate and long range moves to raise metalworking skills.

A STRONG, FULL PROGRAM DESIGNED to upgrade foundry personnel and improve metalcasting technology is drawing close to reality. Two recent steps add new vigor to the AFS Training & Research Institute plans for expansion.

One is the long awaited tax ruling. T&RI has been declared a tax exempt foundation by a ruling of the U. S. Treasury Dept. The other is authorization by the AFS Board of Directors to proceed with the solicitation of funds for the proposed National Foundry Training Center adjoining AFS Headquarters in Des Plaines, Ill.

The tax exempt status removes previous contribution restrictions and allows expansion of the program which has been conducted on a limited basis for four years. The ruling makes possible increased activity in basic research of all cast metals projects proposed by AFS research committees; expansion of technical field services through regional institute courses and programs; the restoration of the Foundry Instructors Seminars for high school and vocational school teachers; a broad program of scholarships; and construction of the National Foundry Training Center.

AFS is pushing ahead with its T&RI program to raise job skills of metalcasting workers. What does this mean to the industry? How will it advance the competitive position of the industry? How will it advance technology?

MODERN CASTINGS contacted industry leaders to get their reaction to the program. Replies indicated that it was long overdue. Only through such efforts can the industry meet competition at home and abroad. It was pointed out that the future of metalcastings lies in the better training and retraining of foundry personnel and castings users. It was evident they felt that AFS Training & Research Institute is the logical medium for conducting this program.

Foundry Closings Point Up Need

The vital importance of the program was emphasized by B. L. Simpson, president, National Engineering Co., Chicago, who stated: "The closing and consolidation of at least 100 foundries in the last six months illustrates graphically the need for training of high grade technicians who can and will keep the industry competitive. No other overall source in the foundry industry is capable of reducing the steady loss of technicians to other industries."

The unique role of T&RI was stressed by F. J. Dost, president, Sterling Foundry Co., Wellington, Ohio. "Now many of the much needed progressive and constructive programs of AFS and T&RI can be launched and provide for our industry the only facility in the United States devoted exclusively to cast metals instruction and research."

Said N. J. Dunbeck, vice-president, International Minerals & Chemical Corp., Skokie, Ill., "This will upgrade skills of a group of workers not reached by other educational programs and will sharply improve the ability of foundries to compete with other types of fabrication."

Relationship of the T&RI program with the needs of the industry were stressed by AFS Regional Vice-President T. T. Lloyd, Albion Malleable Iron Co., Albion, Mich., and AFS President A. L. Hunt, Superior Foundry, Inc., Cleveland.

Said Hunt: "The success of our T&RI courses over the past four years is concrete evidence of management's awareness of the need for improved training and potential supervisory and technical personnel and for the furtherance of research to attain that end. Only by developing and employing the 'better way' can the inroad of competition, foreign and supplantive, be met and reversed. With this tax barrier removed, we can move—we must—forward."

Commented Lloyd: "A key to satisfactory metalcasting profit margins is better products at equal or lower cost. This can be achieved effectively by adapting the best current technology to manufacturing processes and the continual development of improved technology. T&RI's job is to improve the competitive position of the industry by keeping industry personnel technically informed, and probably more important, by developing in such personnel a capacity for forward

Final details and specifications of the Training Center Building were reviewed by the building committee and architects at AFS Headquarters. When completed, the center will be unique in the country.

creative thinking applied to practical every day situations."

In a similar vein, AFS Vice-President J. A. Wagner, Wagner Castings Co., Decatur, Ill., observed: "The operations of foundries each year are becoming more mechanized and more thoroughly controlled. Production men receiving your services will be a great addition to the growing number of engineers and metallurgists coming into the industry, all of whom are needed to supervise these improved facilities and operations. It is only through this teamwork of qualified men and efficient and modern equipment that we can expect to meet the competition of other materials and to provide for better working conditions."

Great Strides Overseas

Not only is the T&RI plan seen as aiding U. S. foundrymen in meeting competition at home but overseas as well. Dost, who served as an official AFS representative at the 1960 International Foundry Congress in Zurich, explained what he learned there.

"I was able to learn first hand the great strides made by England, Germany, France, Italy, Spain, Sweden, Russia, and other countries in research and technology in the cast metal field, and how the industry itself supports these activities. It was immediately apparent that we have no equivalent, as such, in the United States and that if we are to keep pace with our competitiors across the oceans, as well as at home, we would have to prevail until the AFS Training & Research Institute became a reality."

L. H. Durdin, president, Dixie Bronze Co., Birmingham, Ala., and chairman of the T&RI trustees, observed, "The ruling that T&RI is a tax exempt institution paves the way for the next step; namely, the physical establishment of a Training & Research headquarters in Des Plaines. By this step, the United States keeps pace with many foreign countries that have such centers."

Other comments by industry leaders:

Frank W. Shipley, foundry manager, Caterpillar Tractor Co., Peoria, Ill., "Now the Society through its T&RI can accelerate its program of training and research to further advance greater technological improvements in the field of cast metals and thus bring the competitive position of the casting industry up to the level it deserves."

Sam Northington, foundry superintendent, Combustion Engineering Co., Chattanooga, Tenn., "Were I Uncle Sam, I would say to AFS, here is your hunting license, the woods are full of game—technical knowledge that is so badly needed by your starving industry."

C. R. Wolf, president, New Jersey Silica Sand Co., Millville, N. J., "Expanded training and research will improve job skills and leadership. The foundry industry will find itself in a better position to meet competition. Technology will most certainly be advanced with these scientific improvements."

C. C. Salvage, assistant works manager, James B. Clow & Sons, National Cast Iron Pipe Div., Birmingham, Ala., "Training and research educational programs are essential to improvement of the foundry industry. Although it is one of the oldest, there is great need for educational training and research institute programs to improve present day foundry skills. Metal casting will remain a basic industry and we must use every means to improve techniques and processes."

FOR DEPENDABLE SUPPLY

"A.W." PIG IRON is always available from the substantial stocks maintained at Alan Wood. You can count on us as a dependable source for prompt service on any size order.

Close control of A.W. production techniques also assures you consistent, uniform quality for efficient cupola production.

Ironmasters since 1826, we are well versed in metallurgical needs . . . can readily supply you with the correct grade.

Alan Wood services are available to you at all times, including free use of our laboratory. Let us show you how we can help.

For more information, write Manager, Foundry Coke and Pig Iron Sales.

ALAN WOOD STEEL COMPANY
CONSHOHOCKEN, PA.

AMERICAN IRONMASTERS FOR MORE THAN 135 YEARS

Circle No. 150, Pages 145-146

WEDRON

SILICA SANDS

99.9% PURE SILICA
WEDRON
SILICA COMPANY
INDUSTRIAL SAND

WEDRON SILICA COMPANY • 135 So. La Salle Street, Chicago
MINES AND MILLS IN WEDRON, ILLINOIS

Circle No. 151, Pages 145-146

WHAT'S COOKING AT ERIE?

PLENTY! Brand new coal mixing bins, a new screening plant, and new loading stations have just been completed at Interlake Iron's Erie Coke Plant.

These new facilities guarantee you a vastly improved foundry coke.

A NEW AND BETTER FOUNDRY COKE

ERIE COKE

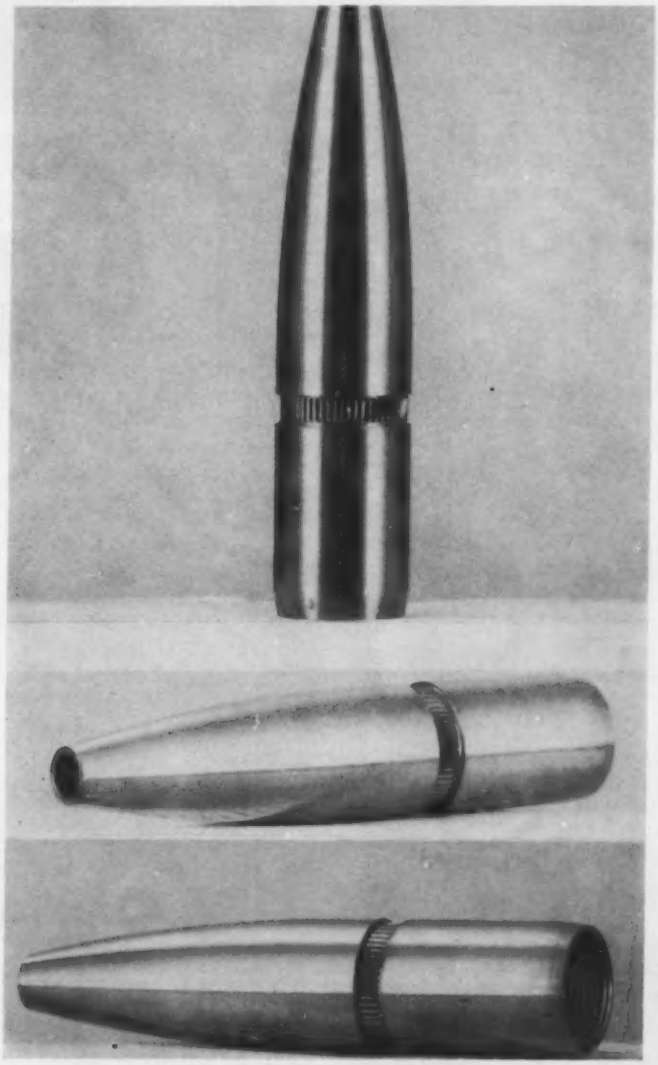
PICKANDS MATHER & CO.
CLEVELAND 14, OHIO

Chicago • Cincinnati • Detroit • Duluth
Erie • Greensboro • Indianapolis • New York
Pittsburgh • St. Louis • Washington

IRON ORE • PIG IRON • SILVERY • COAL • COKE
FERROALLOYS • LAKE FUELING • LAKE SHIPPING

First Success with Cast Uranium

A New Technology breakthrough, first published in the August issue of MODERN CASTINGS, *is revealed as a working reality by the same men who pioneered the technical development. Authors G. D. Chandley, D. G. Fleck and B. W. Crocker, all of Watertown Arsenal, describe a practical application of an "atomic age" metal in the foundry.*



Actual size 20 mm spotting rounds for atomic warhead Davy Crockett weapon. These are cast of uranium—8% Mo alloy.

THE atomic age has brought a new metal to the foundry industry. Generated as a by-product in the manufacture of uranium fuel for atomic reactors, thousands of tons of castable uranium are crowding the nation's stockpiles for want of commercial application.

Recently, the Watertown Arsenal successfully solved the problems of melting and casting uranium and its alloys—first reported in MODERN CASTINGS, August, 1961. Here is a detailed report on the mass production application of this unique material — "spotting-rounds" for the atomic warhead firing of the Davy Crockett weapon, a Jeep-mounted recoilless rifle for front line fighting.

Because uranium-8% Mo has a greater density than any other commercial material, small 20 mm spotting-rounds can be fired in the same trajectory as a heavy atomic projectile. Once the inexpensive spotting-rounds are on target, the atomic warhead is substituted. Ordnance needs for spotting-rounds will run into the tens of thousands.

Designers all over the country are finding commercial applications for uranium wherever there is a need for a high density material to occupy a small volume of space. Already it is used as counter-balances in inertial guidance systems and aircraft wings—wherever space is at a premium but weight is needed.

Uranium costs around $4 a pound compared with its most similar competitive material, tungsten, at around $9. Uranium alloys melt and cast easily at 2350 F whereas tungsten melts at 6000 F.

Cast depleted uranium alloys

as structural materials are unique because of their high yield strength (130,000 psi at 0.1 per cent offset) and high density. The 0.67 pound per cubic inch density of uranium alloys makes them more than 50 per cent heavier than lead on a volume basis.

The most commonly used structural alloy, eight to nine per cent Mo, has the high transition temperatures and notch sensitivity characteristic of body centered cubic metals, but it has been successfully used in severe shock applications. When using uranium to cast 20 mm projectiles, careful thought and application of metallurgical principles are demanded.

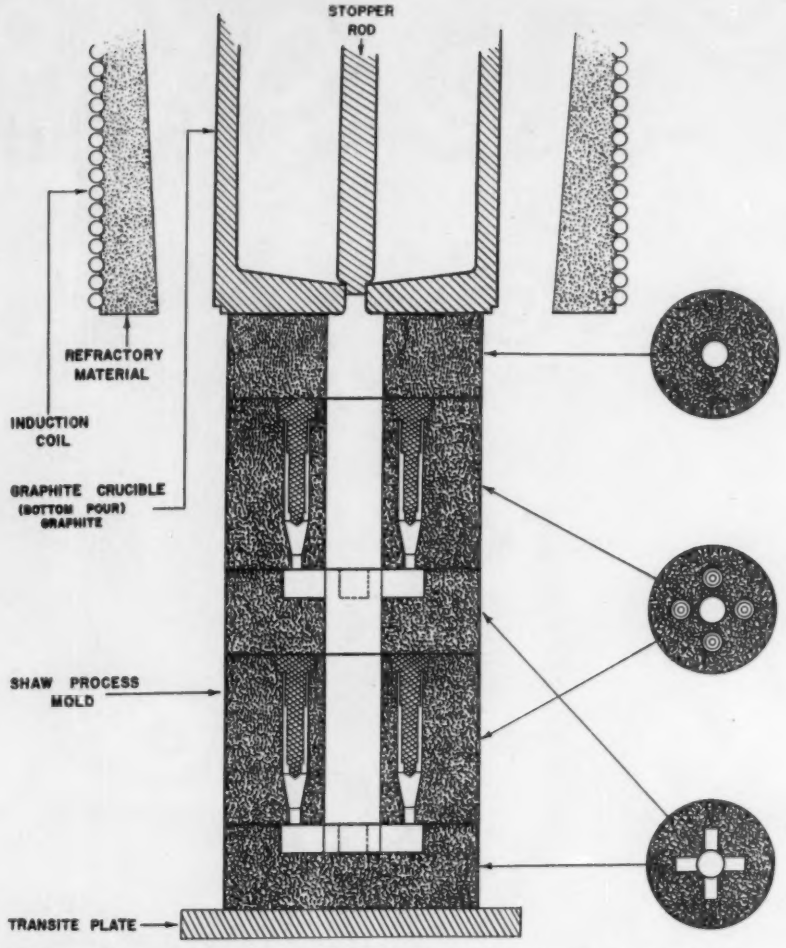
Machining Was Expensive

Previously 20 mm spotting-rounds were machined from bar stock. When this type of projectile was required for the Davy Crockett program, uranium bar stock was specified. This selection was also influenced because little was known about the properties of uranium castings.

In machining the bar stock in production, deep hole drilling required was very slow and expensive because of uranium's tendency to react with cutting tools. Material and machining costs could be reduced by casting the inside of the projectile with only a small amount of finish. Also, machining a contoured casting would be more economical than machining bar stock. For these reasons, a casting practice was developed.

As reported in the August issue of MODERN CASTINGS—"Melting, Casting and Heat Treating Techniques for Structural Uranium Alloys" by G. D. Chandley and G. D. Fleck—ceramic molds can be used to produce uranium castings of fine finish and radiographic soundness. The mold and core used are illustrated here. The mold is a composite, consisting of a coarse Chamotte grog backup coated with a fine zircon facing.

The Chamotte is made up as a preform, and the zircon slurry is poured between the preform and the pattern. The composite mold is then torched and baked out in accordance with standard procedure. The uranium eight per cent Mo alloy is gated and risered in the same fashion as a low carbon steel casting.



Mold sections, right, are made by pouring a zircon slurry between pattern and Chamotte preform. Sections and cores are assembled and placed under a graphite melting crucible heated by an induction coil.

Mold is Refractory

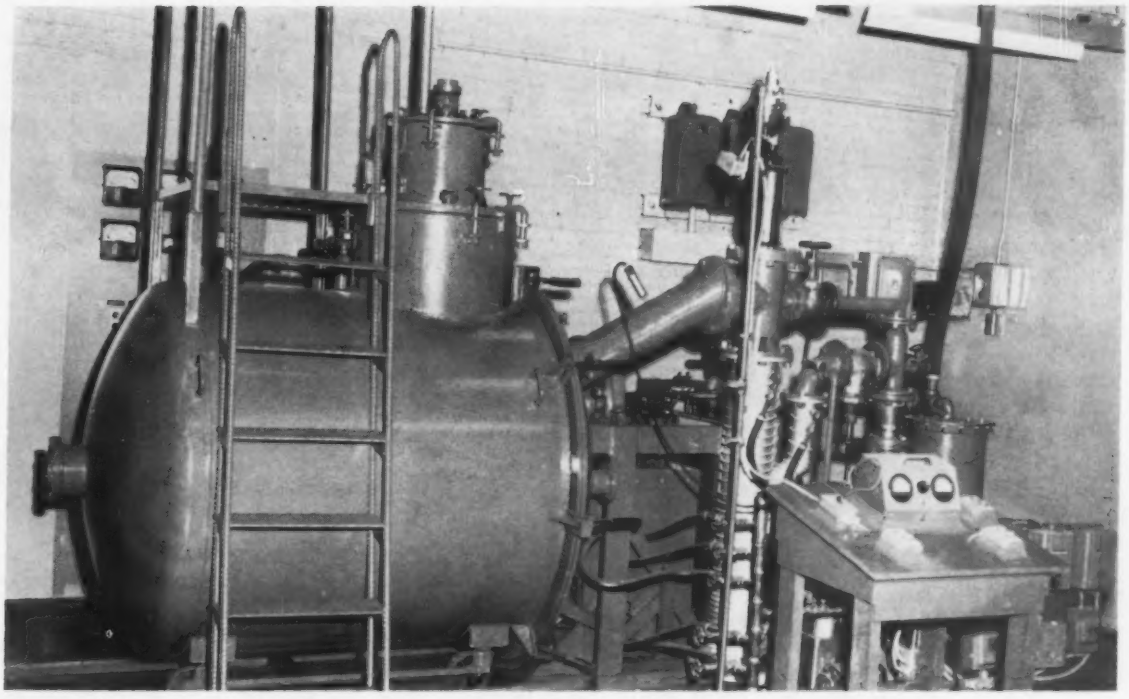
The coaxial melting-casting process, described in August, was used except that the mold is, of course, refractory. Therefore, only minor temperature gradients exist in the mold prior to pouring; gradients induced by flow of metal and risers are required to produce sound casting. The molds can be stack poured.

The graphite crucible is coated with an aqueous zirconite followed by a proprietary wash to prevent harmful contamination of the uranium.

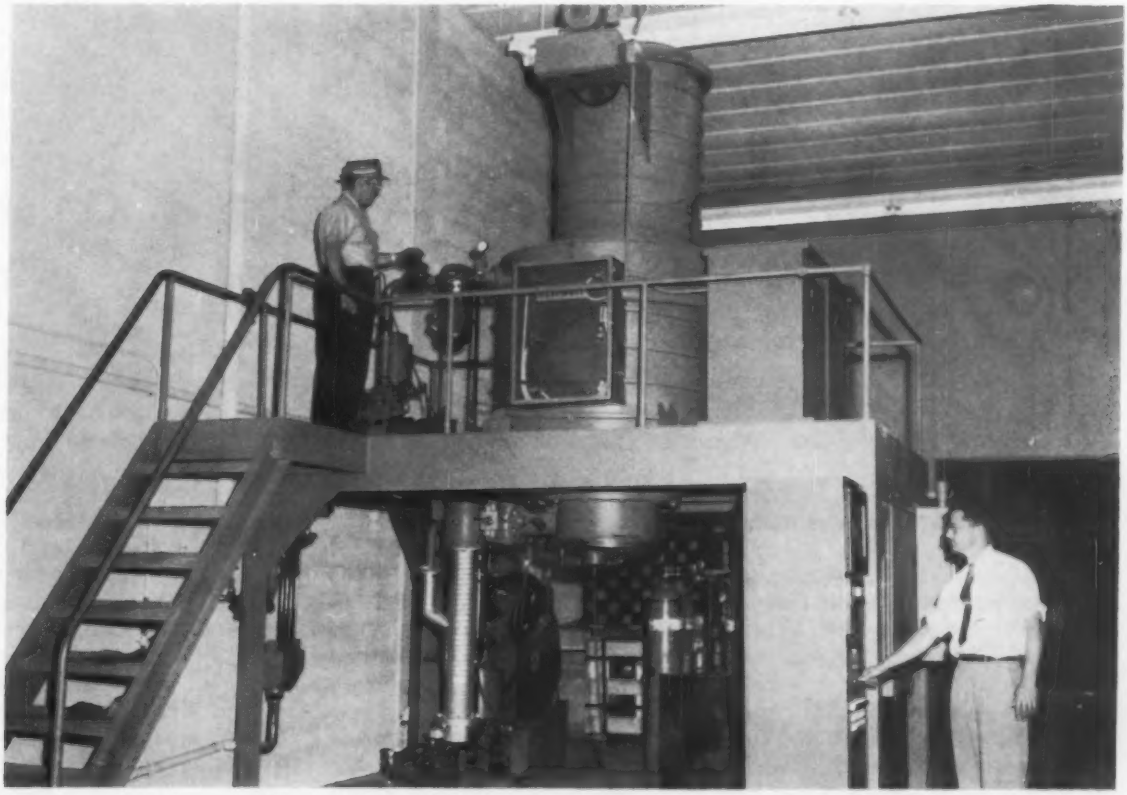
The uranium should be induction melted under a pressure less than 200 microns (2.6×10^{-4} atm.), held to insure homogenization, and tapped at 2700°F. Just prior to the tap, argon is flooded into the chamber to raise the pressure to approximately 0.97 atmosphere to improve feeding of the casting. A picture of the vacuum casting unit is shown on these pages.

During shakeout, the castings must be handled carefully as they contain the delta phase which causes them to be very brittle. In the case of the spotting round, this is convenient because the castings can be easily snapped from the runner.

The refractory cores are loos-



Melting unit and mold are housed in this vacuum chamber measuring four feet inside diameter. Pumping system reduces pressure to 200 microns for melting. Argon is flooded into chamber prior to tapping. This raises pressure sufficiently to improve feeding of casting.



Vacuum heat treat and quenching furnace is used to eliminate the brittle delta phase existing in the as-cast condition. Castings are held 10 hours at 1650 degrees under vacuum.

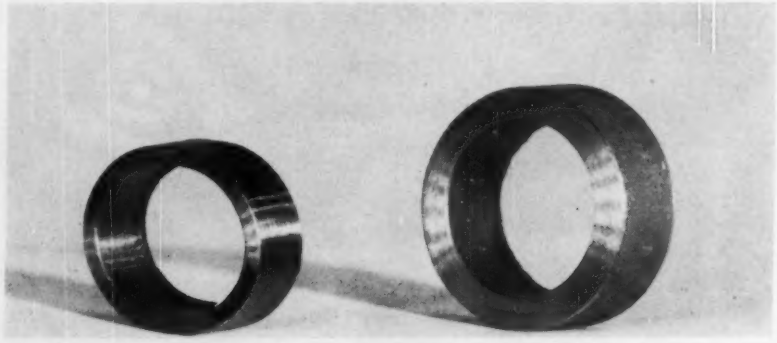
Prior to heat treatment the brittle oxide surface is removed by grit blasting. Castings are acid pickled to yield a gold colored shiny finish.

ened with a rotary tool and sandblasted clean. The castings are radiographed and heat treated prior to pickling. The surfaces of the castings are slightly oxidized producing a very brittle surface. This oxidized coating is grit blasted off or pickled off using the following procedure:

1. Degrease in mild alkaline soak cleaner at 180°F for five minutes.
2. Vapor hone.
3. Dip in the following mixture at room temperature for five minutes: 40° Baumé HNO_3—5 cc with 75% H_3PO_4-100 cc.
4. Rinse and dry.

The castings are gold in color after pickling and have a high sheen.

In the as cast condition, a brittle delta phase, should be dissolved by heating into the gamma field and cooled rapidly in air or oil to room temperature. This retains the body-centered cubic gamma structure. In practice, the castings are heated to 1650°F for ten hours under a vacuum of less than five microns (6.50×10^{-6} atm.) in a vacuum heat treat and quenching furnace. They are oil quenched. The shape of projectiles precludes sampling for tensile properties.



Quality of metal is checked by compressing an as-cast ring. The ring should compress 40 per cent of diameter before fracture. See left.

Since the base material strength is never below 120,000 psi, 0.1 per cent, yield strength, the quality of the metal is checked by compressing a ring. If the ring compresses 40 per cent of its original diameter prior to fracture, the analysis and heat treatment are considered acceptable. Before and after compression samples are shown on this page.

Uranium casting procedures may seem unusual now—but with development of castings of titanium, molybdenum, tungsten, and other "space age" metals, the procedures will be commonplace in the next few years.

The main point is that there is an abundance of this castable, dense metal available for use. New technology has produced a means of working with the metal, and it remains for the foundries to apply this technology to profitable industrial developments. Maximum weight in minimum space is perhaps a new concept, but a valuable one.

Does Your Foundry Qualify?

For every contract that is awarded to a foundry, there are anywhere from one to several metalcasters who bid but who fail to get the job.

Why?

Frequently, it seems, undue emphasis is placed on price. The disgruntled loser is apt to permit the price factor to satisfy his cry: "Why didn't we get the contract?"

This isn't always the truth. Considering price alone may obscure other —and more important— reasons that delivered the contract into competitive hands.

J. H. Rizley, chief materials and processes engineer of General Dynamics' Pomona, Calif. plant, explains what is needed in this thoughtful article. He outlines the factors that influence his decision in selecting a casting supplier.

How do you rate in terms of his evaluation?

PUT YOURSELF in the place of a castings buyer. How would you go about selecting a foundry? The rule-of-thumb is simple and direct: can he supply a premium quality product and make delivery when I want it?

Although the rule may be simple, application to a given foundry is not. It is true that the foundry industry has always tried to fulfill the engineering demands of castings buyers. But technological developments in the past 15 years have placed additional heavy burdens on all industry.

Only after careful appraisal of a foundry in these terms can a contractor intelligently award a contract. How can we make such an appraisal?

In the metalcasting industry, the continuous demand for better mechanical properties, higher structural integrity and complete reliability has crystallized a new approach when qualifying casting suppliers. Principal reason: more castings are now used in critical applications.

These new applications involve a tremendous capital investment in aircraft, missile or space hardware, and more important, the lives of passengers, astronauts and ground handling crews.

When we think in terms of design changes and property requirements, commonplace with present-day products, it is clear that foundries must be flexible so they can make these changes without serious operating interruptions.

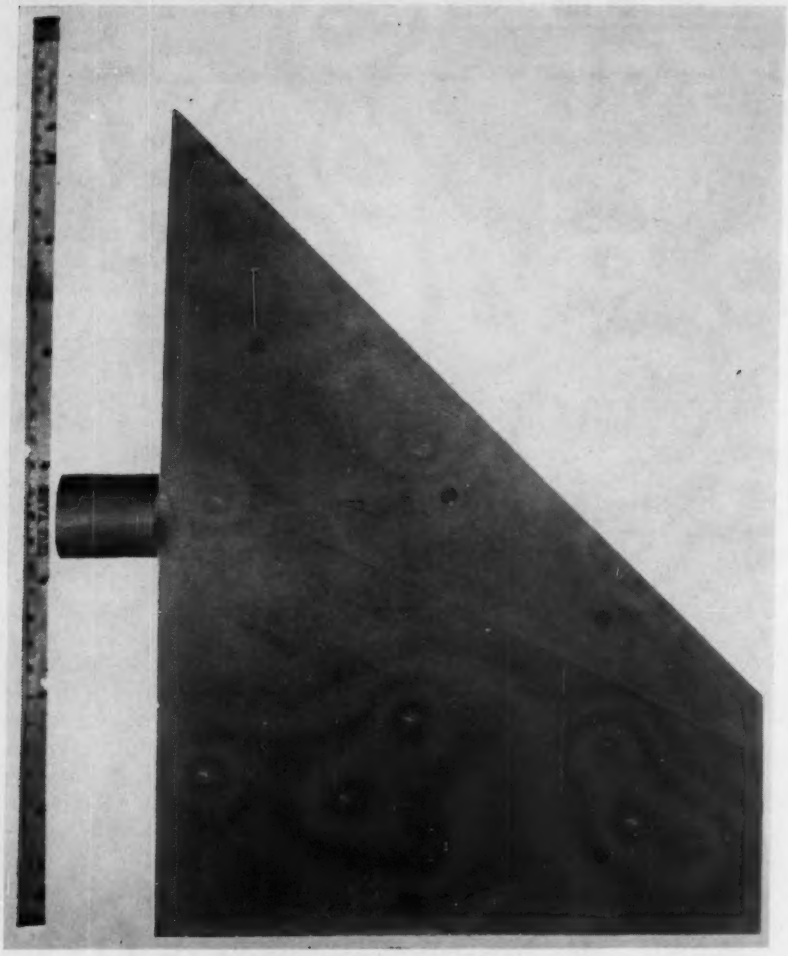
Most contractors, when evaluating a foundry, would use the following factors:

1. Facilities
2. Raw materials
3. Quality control
4. Personnel
5. Financial stability
6. Integrity
7. Cooperation

Taking a closer look at these seven major factors reveals that each is important in itself, and each must be backed up by the other six to be effective.

1. FACILITIES—Size is not always important. In fact, a poll of contractors reveals that small foundries do much of the outstanding work today. Look at Picture No. 1. This is a missile booster fin—a cored sand casting in magnesium alloy AZ-91—requiring special equipment and skills, not floor space. Facilities needed to produce this casting must be modern and reliable, not just large.

2. RAW MATERIALS—A quality product cannot be made with second grade raw materials. This does not prohibit use of remelted scrap—but it does mean that strict control must be maintained over the alloy composition of scrap along with suitable refining methods. The proportion of scrap



1. This missile booster fin requires special equipment to produce, not any special floor size area or plant size. Bigness alone is not enough.

to virgin pig must be kept within reasonable limits.

3. QUALITY CONTROL—Contractors look for an organized and well defined quality control plan. It practically dictates the degree of reliability in the production of castings. This is particularly true when we are concerned with a premium quality product.

How do we determine if a foundry has a good quality control plan? Let's begin with procurement of raw materials. Conformance of alloys to chemical composition, proper segregation of alloys in house, good housekeeping and maintenance of accurate records all contribute toward a reliable product.

Foundry process control is perhaps the most influential factor in a sound quality control plan. It reaches into every facet of foundry production. Proper certification of temperature measuring instruments, control of sand and metal analyses, temperature uniformity of furnace equipment, accuracy of mechanical property data, proper identification of castings—these and other factors can make the difference between excellence and unreliability in the finished product.

An inspection plan for dimensional and other nondestructive tests must also be a part of the overall quality control system. Lack of such procedures frequently can entail undue expense for both the contractor and supplier.

An organized quality control plan usually folloys a detailed manual that outlines the procedures followed. Our own experience has shown that jobs which have run successfully for several days may suddenly get into difficulty. Almost without exception the problems are traced to an area where quality control plans are not followed, or have not been adequately documented for use by a new employee. My own organization avoids foundries that have not shown a healthy respect for quality.

4. PERSONNEL—The degree of competence of engineers, metallurgists, pattern makers, molders, inspectors and all other personnel, contribute heavily to the manufacture of a superior product. Lack of competent personnel can sharply reduce the potential of an organization.

5. FINANCIAL STABILITY — Financial stability obviously is necessary. But this doesn't mean that small businesses will be excluded by the contractor because they are small. Even the big foundries can get into financial troubles.

Misinterpretations of the requirements, changes in design, modification of physical or mechanical properties, over-confidence, overselling, and other factors may result in serious financial distress with a contract.

6. INTEGRITY—Everyone likes to exhibit confidence in his ability. But sometimes there is a fine line of distinction between over-confidence and lack of integrity.

Delivery schedules for aircraft or missile hardware are based on need times for an assembly or product delivery. When these schedules are not met, the reputation of the foundry suffers. Relations with contractors may be jeopardized.

7. COOPERATION—Important and intangible, cooperation is a two way proposition. Without cooperation between the contractor and the foundry from the time a design is conceived, needless and serious problems may arise. Ideally, consultation with foundries is desirable from the time a designer begins his work until the last casting of a contract is delivered.

Don't ever assume that because a casting has been in production for some time your problems are over. Picture 2 shows an investment casting of involute configuration made of 17-PH stainless steel. This casting has been in production for several years, always with two supplier sources.

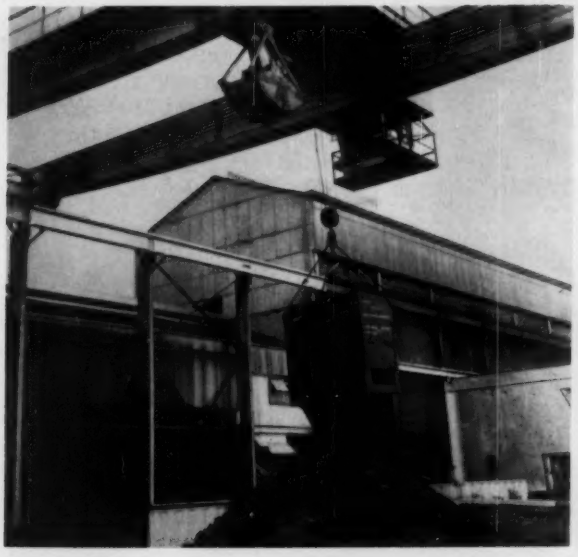
Four different foundries have been supplying the casting and we still occasionally encounter problems which have not been met before. Some of these problems may result from the particular method of casting or a certain balance of the chemistry in the alloy which may be within specification but will not produce acceptable mechanical properties. Sometimes we are troubled by personnel problems and other factors. But all these problems generate situations that require cooperation between contractor and supplier.

Not all contractors use the same bases for evaluating a foundry as we do. The particular demands of a given job may introduce additional factors or put special emphasis on those discussed here.

Probably the most important thing for a metalcaster to bear in mind is that he must always be prepared to fulfill this basic formula: *Adequate Facilities + Premium Quality Raw Materials + Competent Personnel + Top Quality Control + Good Cooperation and Integrity = Premium Quality Castings and Future Contracts.*

2. This stainless steel investment casting has been in production for several years, yet some suppliers still encounter new problems in making it up to standard.

Kraft bags are the popular containers for many of the bulk materials. They can be used to advantage if they are moved at low cost.



Metal shipping containers carry coke at the International Harvester ductile iron foundry in Memphis, Tenn. Speed here saves demurrage cost.

Newest means of handling bulk materials is the rubber bag.

You Can Save Money Moving Bulk Materials

Some point-by-point ideas on cutting the cost of moving the everyday bulk materials in your foundry—from a man whose business it is to know. R. J. Gildea, supervisor of the Materials Handling Research Lab at International Harvester, is the author of this "Operations for Profit" article.

EVERYBODY talks about the cost of materials handling in the foundry—but hardly anybody does anything about it.

In one area alone—moving bulk materials such as bentonites, seacoal, oxides, and other additives —it is possible to control and cut costs by the simple means of careful planning.

How much can be saved? It's difficult to generalize because each foundry faces its own problems. However, individual studies show that 50 to 80 per cent of the cost of handling materials can be slashed (MODERN CASTINGS, July 1961, page 42), if the metalcaster is willing to devote time to planning.

For the most part, foundries are geared to multi-walled kraft bags for handling small bulk materials. Suppliers favor the bags because they are easy to fill and strong enough to hold the materials. Foundries generally are satisfied with kraft bags because one man can lift, carry, and place into position a filled bag with no more than normal effort.

The bags cost between 10 and 13 cents each, and normally hold about 100 lbs of seacoal, bentonite, or whatever is called for. They are not, of course, reusable. This combination adds up to two immediate advantages—comparative low cost and convenience of handling (a time cost factor).

The real savings just begin here! Actual profit lies in the planned movement of materials through the foundry processes, from the supplier's plant to the end use.

Planning can effect savings in three areas: (1) movement into the foundry, (2) movement within the foundry, and (3) distribution.

To initiate an immediate saving before the materials reach the foundry, the metalcaster can take

positive action in five steps—each designed to save money.

He can:

(1) Look into quantity purchases. Has the best and least expensive shipment size been established? Is the best freight charge in effect?

(2) Maintain an accurate control of direct and indirect costs. Before costs can be lowered they must be known and understood. It is up to the metalcaster to have or get this information in detail.

(3) Have loads palletized when possible. This may or may not be done by the supplier. It is up to the foundry to locate a supplier who will cooperate fully to keep costs down.

(4) Designate a specific storage area with adequate protection against dust, fumes, and fire hazards. The way materials are stored and the volume that can be stored adds up to dollar savings. Careful planning here can speed the entire casting operation by having the material ready and accessible when it is needed.

(5) Have the proper unloading equipment and facilities available. A capital outlay for the proper kind of materials handling equipment usually will pay off in hard cash savings.

Many plant layouts can be modified to increase efficiency. But careful and continuing study of the existing system is essential. New installations, when they are well planned incorporate all of the best ideas.

To plan movement within the foundry, metalcasters should consider these 10 points:

(1) Move materials in as straight a line as possible.

(2) Keep storage facilities as close to their point of use as practical.

(3) Allow sufficient room for wide aisles and storage areas.

(4) Utilize "air rights"—stack as high as possible.

(5) Provide sufficient and adequate equipment to move materials.

(6) Coordinate plant production schedule with the plant layout.

(7) Allow for sequence handling of materials to insure better flow and less time loss.

(8) Plan or modify facilities in line with the objectives of the plant.

(9) Maintain proper storage areas for materials on the move.

(10) Allow for changes in the future.

It is important for a metalcaster to review his system from time to time. Although kraft bags are commonly used throughout the industry, they too, offer problems. Many times the unloading area becomes dusty and presents a health hazard. Proper ventilation or a totally enclosed system will remedy this situation.

Costs rise if the bags must be palletized in the foundry and de-palletized for stacking in the storage area. If the supplier will palletize bags at his plant, without charging a premium, handling at the foundry is simplified and costs are minimized.

In some cases, even payment of a premium will reduce over-all costs. However, it is as cheap to move 20 100-lb bags on a pallet as it is to move one 2000-lb container on a pallet.

Corrugated container suppliers are attempting to produce substitute containers that will do a better job. These containers vary in physical appearance, but most have a liner, a top, a bottom and an exterior shell. Like the bags, they are not reusable.

Some are assembled with steel bands, others have special devices to prevent spillage or damage. These containers are good within their range and need. They transport well and are superior in strength to the multi-wall bags.

Corrugated containers are clean and seldom split or break in handling. There are both simple and elaborate devices available for emptying them.

The principal disadvantages of these larger containers are size (one man cannot handle a unit without equipment) and cost. A single container probably costs two and one half times the equivalent number of kraft bags.

Another type of container now used by some large foundries is a metal shipping container. These units have a relatively high initial cost, and they are usually leased. They can be reused many times. Primarily designed for large purchasers, the metal containers offer advantage of possible outside storage (freeing expensive indoor space) and better shipping rates.

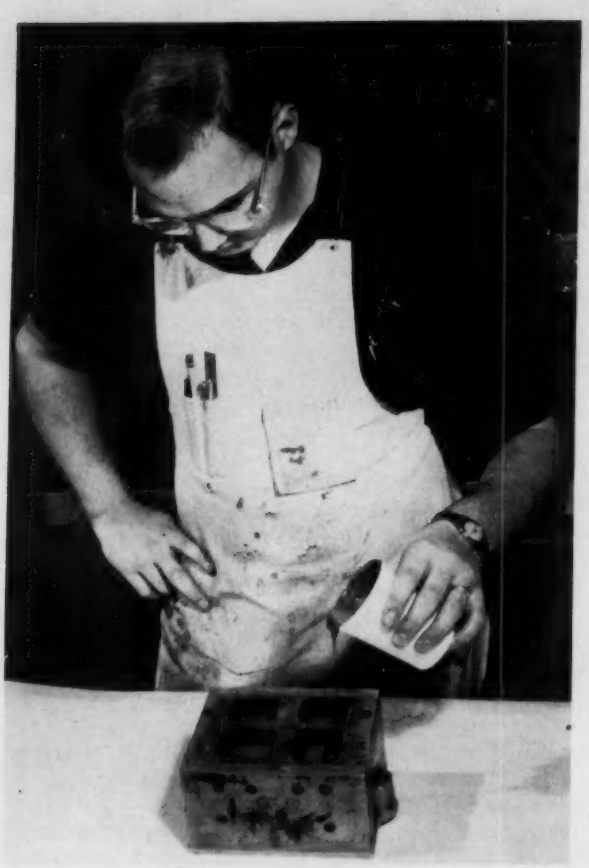
More elaborate emptying devices are required because of the increased capacity and tare weight of metal containers. This, however, becomes part of a complicated but more economical system if sufficient quantities of the material are demanded.

There is one other type of container worth considering—the collapsible rubber bag. This is available in a variety of sizes and requires special emptying equipment. Rubber bags are usually leased or purchased like the metal containers.

They are reusable and generally can be employed for several years. They will obtain lower freight rates if carried in sufficient quantities.

Indictments that some materials settle in these bags and are difficult to be removed were disproved, at least in the case of seacoal and bentonite. Studies showed that normal agitation was sufficient to remove the contents.

High-priced containers for low-priced commodities doesn't make sense unless proved savings in time and money can be effected. A foundry with no inside storage space can justify the more expensive containers, just as the small foundry can justify the use of kraft bags. There is no single answer, but there is always a right answer if the metalcaster will look for it.



Mixture of epoxy resin and hardener are poured in a mold for four inserts. It takes 30 minutes to set up the mold and seven hours to cure.

The varied-shape inserts are placed in the corebox at points of excessive abrasion. They are thrown away when they begin to show wear.

Plastic Inserts Reduce Corebox Wear

"Throw-away" epoxy resin inserts are used at the Buick Motor Division foundry to protect coreboxes from excessive wear in "hard to reach" spots. These units have replaced iron and steel inserts of far greater cost—eliminating the need for repairing or patching.

COREBOX INSERTS made of epoxy resin instead of iron or steel are performing a highly satisfactory service in the foundry at Buick Motor Division, General Motors Corp.

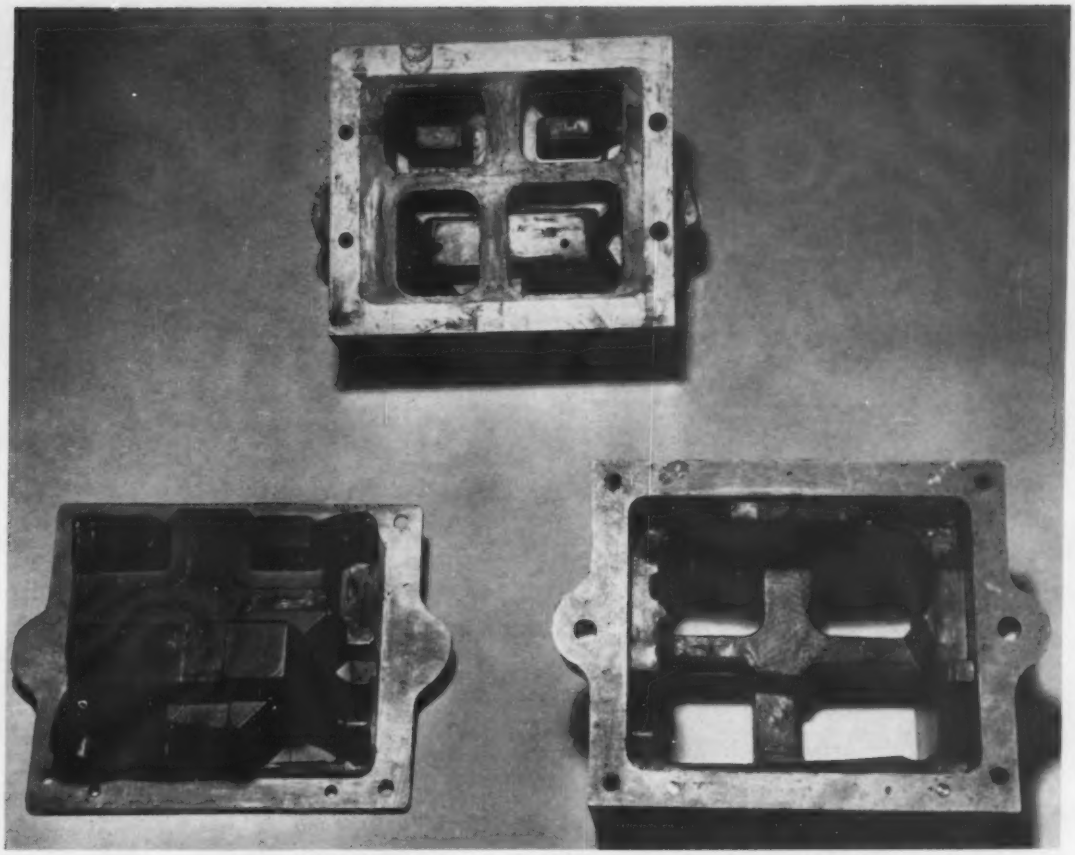
In making cores for exhaust manifolds and intake manifolds, several areas in the coreboxes are subject to excessive abrasive action by sand as it is blown into the box.

As is usually the case, the heavy wear areas are in "difficult-to-reach" spots which make it hard to machine or scrape. To combat this problem, it is common practice to make removable inserts which replace the worn sections at frequent intervals.

Previously at Buick the inserts were made of metal—either iron or steel depending upon the corebox material itself.

40 Hours for Metal Insert

There was no way to make the inserts except with three-dimensional duplicating equipment operated by highly-skilled machinists. It took a minimum of 40 hours to make a single insert which had a maximum service life of 40 hours. Some inserts were so complicated they required as much as 120 hours to complete—still giving 40



Closeup of the molds used for casting the inserts. Mold at the top shows mold ready for casting. Bottom two show details. The right part fits on top of the left to form mold.

hours of service. This often included soldering and patching to keep the units in use.

Today the foundry makes as many as 20 plastic inserts a day and uses as many as 350 at one time in all coreboxes. This represents a savings of 91 per cent of the previous cost of the operation.

A plastic insert is thrown out as soon as it begins to show wear—this saves the time and money involved in patching. The epoxy resin inserts have the same service life—40 hours—as the metal, but actually cost less to duplicate than it took to repair a metal insert.

The idea of using plastic inserts and the method of making them is credited to Ralph Blades, a Buick pattern designer. He was asked by C. L. Koch, general assistant superintendent of pattern shops, to make a study of operations and equipment in the Buick foundry with the thought of effecting savings in high-expense areas. One idea to evolve was the use of plastic inserts.

The first problem he solved was the design of the molds for casting the plastic. He developed multiple cavity molds in which four inserts are cast simultaneously. The finished parts are easily knocked out of the mold when they have been cured.

To produce the mold, a master pattern or the metal core box insert is placed in a wood or aluminum frame. A liquid parting material is brushed over the surface of the metal insert. The epoxy material is poured into the frame and allowed to cure. The mold is then separated and the pattern removed.

Less than Eight Hours for Four

To make the inserts, the mold is fitted together and brushed with liquid parting agent. It is then filled with the epoxy resin slightly above the required level to allow for machining flush to the flat surface of the mold when cured. This assures an accurate base, finished to exact dimensions.

It takes 30 minutes to set up four inserts in a mold. These are cured at room temperature for seven hours—a far cry from the 40 plus hours formerly required.

The production and use of plastic inserts was passed on by Buick Motors to other GM divisions through the technical information exchange. It was reported that Chevrolet is now using some plastic inserts in foundry equipment. Basically, the idea has not moved out of the automotive field, although there is room for close investigation by many metal-casters.

COVER STORY

Castings Play Vital Role in Space Travel

TWENTY-ONE CASTINGS help carry American astronauts into space every time a Mercury capsule is fired at Cape Canaveral.

This month's cover picture is our artist's conception of the capsule as it sits on a test platform and one of the major castings—a H_2O_2 shut off (roll) for the bellcrank assembly.

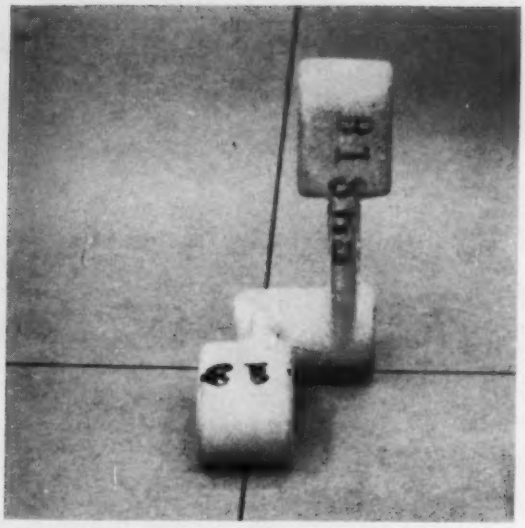
The casting, like the majority of those used and pictured here, is AZ 91C-T6 magnesium alloy. It is a green sand-CO_2 core mold casting produced by Artra Machine & Foundry Co. in St. Charles, Mo.

Two other castings used include the grip assembly-abort (pictured right) which is molded in green sand with CO_2 cores and the yaw unit on the bellcrank assembly (pictured right) which is a dry sand mold—oven baked cores. The grip-assembly-abort unit is part of an assembly which the astronaut has direct contact with during flight. The bellcrank assembly-yaw unit is produced by General Magnesium Foundry in Belleville, Ill., the grip abort by Artra.

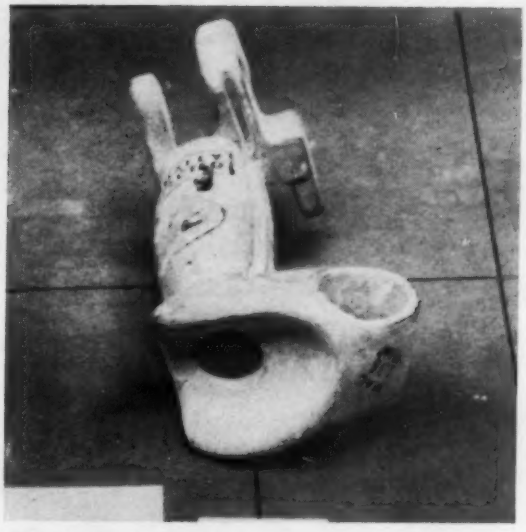
Some of the other interesting castings used in the Mercury include a hand controller for the torque tube assembly, a support for the abort handle, the manual system shut off for the bellcrank assembly, the H_2O_2 shut off (pitch and yaw) in the bellcrank assembly, and pitch and roll units in the bellcrank assembly.

The torque tube assembly hand controller and the abort handle support are both parts of assemblies that come into direct contact with the astronaut and their action is vital to his life. Both are green sand mold and both are highly stressed.

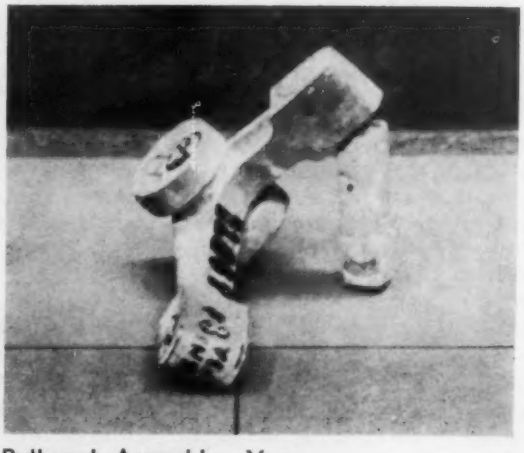
All of the castings used in the Mercury capsule undergo 100 per cent Zyglo inspection, and the raw casting tolerance requirement is plus or minus 0.03 inches.



Bellcrank Assembly H_2O_2-Shut Off (Roll)



Grip Assembly—Abort



Bellcrank Assembly—Yaw

Today, nearly everyone in the metalcasting industry is familiar with the specific properties of ductile iron. But not everyone, it seems, reviews these properties when considering the use of ductile iron for a new application.

In addition to its ductility, this alloy offers design versatility not usually found in other metals or alloys. It is easily cast in both light and heavy sections and in intricate shapes that present knotty problems when using other alloys.

Ductile iron's properties are not directional (compared to forgings) and, though tough, it is easily machined. It has a relatively high yield strength compared with its ultimate tensile strength. It can be supplied in various hardnesses and is adaptable to surface and localized hardening.

Finally, ductile iron has excellent corrosion resistance related to plain carbon and low alloy steels. This makes it especially valuable in marine applications where salt water and a salt laden atmosphere are present.

Ductile Iron—Youngster with a Bright Future

Reported by JACK H. SCHAUM

DUCTILE IRON was introduced to the castings industry in about as dramatic a setting as Hollywood could have staged.

The time: May, 1948. The setting: the AFS Castings Congress in Philadelphia. The players: H. Morrogh, a British Cast Iron Research Association metallurgist, and T. H. Wickendon, vice president International Nickel Company.

Morrogh came from England to present a paper describing a new metalcasting technique. He revealed to his audience a process of making ductile iron castings by the addition of cerium to a composition of gray cast iron having low sulphur and phosphorus contents.

Hardly had Morrogh sat down when Wickendon asked for the floor. He then broke the news of a similar process developed by his company. The difference was that the American process used magnesium instead of cerium. Working independently, metallurgists in England and the United States had simultaneously created the same new engineering material.

In this fashion a controversial child was born. Metalcasters have disputed its value, practicability, virtues and failings ever since. But the obvious versatility of the new alloy set all metalcasters astir. Ductile iron quickly aroused the imagination of the entire industry.

MODERN CASTINGS was first to report Morrogh's new technology in full—April, 1948 issue.

Within a year, ductile iron was applied commercially in this country. The INCO process became the accepted standard, and foundries today, for the most part, manufacture ductile under a licensing agreement with that company.

Ductile iron's acceptance by American industry has been phenomenal. In 1951, only about 7,200 tons of ductile iron castings were produced in this country. In 1961, total tonnage of ductile will be somewhat more than 200,000 tons.

Market opportunities seem to be endless. Ductile has already been put to hundreds of uses and more are reported daily.

Conversion Is Easy

Perhaps the most significant factor about ductile iron is that gray iron foundries can convert readily to the production of ductile. In a dynamic technology, this is important. It has unquestionably pulled the chestnuts out of the fire for many gray iron foundries which made up for a reduced demand for gray iron by switching to ductile.

Ductile iron (nodular or spherulitic, if you prefer) is an engineered alloy with properties and costs between gray iron and cast steel. It is produced by the addition of magnesium to molten iron in sufficient quantity to produce a residual content in excess of 0.04 per cent. This causes the graphite to precipitate out in nodular form as the metal solidifies and cools to room temperature. What's the future?

In a survey conducted by MODERN CASTINGS, leading metalcasters across the country offered estimates ranging from, "will increase by 50 per cent each year," to "growth will triple in next five years."

Whatever figure you prefer, it is clear that ductile iron has a

growth potential limited only by the industry that produces it.

Although ductile is used widely in hundreds of applications, its acceptance by industry has not been trouble free. While it is true that many carefully run foundries produce first-class ductile iron castings under the most exacting quality control conditions, it is also true that some foundries produce "bootleg" ductile iron that fails to conform to expected standards.

Magnesium Not Enough

Licensed foundries are provided with detailed technical data that, if followed, will produce a superior product. Too many foundries have skirted exacting metallurgical control and assumed that throwing some magnesium into a ladle is all that's needed to produce ductile iron. Nothing could be less accurate.

Then, too, in their eagerness to get into the market, some reliable foundries have produced castings of ductile iron that should not have been made of this alloy.

Ductile iron provides a burgeoning new market, but one that must be entered cautiously to prevent castings buyers from experiences that sour them on the use of the material.

The need for sales engineering was never more important than in developing the ductile iron market. An intensive educational program must be established. Thorough two-way communications must be maintained between producer and buyer so that engineering departments in all industries are constantly brought up-to-date on the advantages of ductile iron castings over another alloy or forming process.

It all adds up to this: ductile iron is here to stay. It has properties that make it the most suitable alloy for hundreds, even thousands, of applications.

Probably the most important factor in expanding the ductile iron castings market is qualification of foundries. Many metalcasters believe that ductile's competitive position will be seriously jeopardized by indiscriminate licensing. It points up the necessity of alerting buyers to which foundries meet top specifications —and which do not! Virtually all metalcasters who replied to MODERN CASTINGS survey stressed these points.

The need for intensive study to determine applications where ductile iron castings are *superior* to any other casting or forming process is obviously the key to further substantial growth.

Harry H. Kessler, president, Meehanite Metal Corporation, New Rochelle, N. Y., believes that ductile must go through about the same growing pains that gray iron did three decades ago. Kessler says that ductile iron got off to a fast start because "the glamour of ductibility gave it a dramatic entrance into the field."

An Eight-Point Program

Stuart Foundry Company, Detroit, last year supplied more than 1500 tons of ductile iron castings to the automotive industry in the form of dies and ingot molds. President C. F. Mally offers this eight-point program that he declares is essential to the development of the ductile iron market:

1. Cost reduction — best accomplished by careful selection of the right equipment and utilization of cheaper scrap. Only an efficiently run foundry can produce superior ductile castings at a competitive price.

2. Educating the buyer — engineering departments of various industries must be well-informed. They must know the advantages of all types of ductile iron; uniform specifications and testing procedures for producers as well as buyers must be established.

3. Quality data — purchasing departments must be supplied with uniform quality data, simply expressed, so that they may intelligently appraise ductile iron producers.

4. Why use ductile? — producers must search for advantages such as simpler design, reduced weight, improved strength, absorbtion of greater shock and stress analysis to provide better service.

5. Research — metalcasters must conduct continuing research and testing to find additional applications of ductile iron.

6. High temperature applications — there must be greater use of ductile iron in elevated temperatures by using heat-resistant alloys; metalcasters must investigate the development and application of ductile in low-temperature applications.

7. Localized heat treatment— increased wear and strength can be developed by research involving heat treatment and tempering.

8. Super-hard ductile — particularly the mining and road building machinery industries are markets for super-hard products.

Through the application of improved technology, costs of ductile iron will come down. Some metalcasters have already found ways to produce ductile at a cost that permits them to bid against many other processes.

What are these cost-savers? Henry McWane, president, Lynchburg Foundry, Lynchburg, Virginia, names these: better methods of adding magnesium, improved inoculation procedures, improved control of base metal composition and temperature, simplification of shop controls without sacrificing reliability and improved molding technique.

Applications Flow In

Reports of new applications of ductile iron castings have been flowing in at such a rate that a simple listing of them would take many pages. International Nickel, for example, believes that there are now more than 100,000 unlike components in some stage of established use, pilot use or proof tested and approved for use.

The list on the next page may shed some light on the current and potential application of the versatile alloy.

Precision Manufacturing Company, Plano, Texas, recently developed a ductile iron casting for oil field equipment to replace three pieces of steel tubing. Willis C. Brown, president, says that previously the part was made by enlarging one end of a piece of seamless steel tubing by swaging, then machining the swaged part and finally, welding pipe collars to the swaged end to provide the outlets.

The ductile iron casting which replaced the welded assembly was cast to close enough dimensions that the only machine operation was to thread the casting at four places.

Ductile Used For Valves

Ductile iron is now used by one of the largest oil refineries as a 100 per cent replacement for steel valves and fittings in 20° to 650° F applications. And the City of New York recently approved ductile iron fittings in standpipe service and sprinkler systems.

The Lynchburg Foundry now makes more than 200 different ductile iron castings. They range in weight from a fraction of a pound to about 500 lbs. A good example of this foundry's work is a ductile iron casting that replaced a weldment for a crank arm of a haybaler. The changeover resulted in cost savings as well as a more efficient working part.

One of the largest ductile iron castings ever poured was a crossrail for a milling machine manufactured by the Ingersoll Milling Machine Company. The adjustable rail milling machine is the first of its size designed to machine mill housings in excess of 400,000 lbs.

The all-important crossrail was cast by the Beloit Foundry Co., Beloit, Wisconsin and weighed 81,000 lbs. The casting contained 1.30% nickel, 0.50% manganese, 2.40% silicon, 3.20% total carbon and about 0.50% each of molybdenum and chromium. Ductile iron was specified to assure strength and rigidity.

J. E. Rehder, vice president technology, Canada Iron Foundries, Ltd., Montreal, notes that a major new application is ductile iron pipe made by the Delavaud or sandspun processes. He says that minor quantities have been sold for gas distribution systems but that next year will see significant replacement of gray iron pipe for water distribution.

Auto Makers Interested

The automotive market—that giant of giants—has taken a significant new interest in ductile iron castings. (MODERN CASTINGS, September, 1961.)

Ford Motor Company is probably the leader. It began production of ductile iron cast crankshafts for passenger cars some eight or nine years ago and now has cast more than 19 million of them.

General Motors, Ford and Studebaker-Packard all have ductile iron engine blocks at the experimental stage and will probably announce them for regular production in the next year or two.

This should be heartening news to those who have been alarmed by spectacular success of cast aluminum engine blocks and other automotive parts.

Although ductile iron castings have assumed importance and acceptance during the past 10 years, this facet of the metalcasting industry still has a long way to go. Ductile iron technology must continue to advance. Costs must come down. And the advantages of ductile iron over other castings or weldments must be sold to engineers throughout all industries so that they will specify ductile iron or at least consider it. Finally, there must be a stabilization of standards so that ductile iron castings hold up to specifications.

Quality control seems to be the biggest problem today. As Russell C. Johnston, sales manager, Crown Iron Works Co., Minneapolis, puts it: "Rigid quality controls are badly needed. Quality control failures are bad in cast iron but in ductile iron they are disastrous. There can be no equivocating."

Getting more specific, C. F.

DUCTILE IRON—WHAT'S IT USED FOR?

Since ductile iron castings first appeared on the scene some 10 years ago, this versatile metal has captured the attention of the foundry industry. Its applications already are too numerous to list. Every day, it seems, another use for ductile iron castings is found.

Here are a few of the newer applications which have been developed by imaginative metalcasters.

- missiles and projectiles
- construction equipment
- pressure tanks
- ship machinery
- military hardware
- castings that must withstand extremely cold weather
- ingot molds
- continuous casting machines
- ductile iron rods
- corrosion resistant alloys for chemical industry
- wear resistant parts
- hydraulic valves and pumps
- engine blocks
- agricultural machinery
- power transmission and fluid handling
- pressure pipe and tubing
- hot forming dies and explosive forming dies for aircraft and missile structural parts
- crankshafts
- electrical and general machinery parts
- automotive parts.

Mally declared, "We must see widespread use of X-ray and ultrasonic testing. There should be more extensive checking of pearlitic and ferritic structures by magnetic comparison. And the industry must make greater use of metallography to insure constant high quality ductile iron castings."

Despite the withering criticism directed to producers of ductile iron castings, rapid progress is being made by some metalcasters to overcome current shortcomings. Extensive data concerning the reaction of ductile iron to heat treatment is now available — particularly with respect to unusual applications where heat treatment may mark the difference between success and failure of the casting.

Many advances have been made in the technology of gating and risering ductile and the use of rigid molds and control of solidification of metal in strategic areas within the casting.

Studies have been made and data collected on use and effects of inoculation after the magnesium has been added. In fact, every month sees new inoculation methods and better chemical control systems applied to ductile iron.

There is still a big gap in sales engineering. Too few ductile iron metalcasters have developed effective plans that permit their engineering departments to function in close conjunction with customers and potential customers.

But ductile iron is far and away the most exciting new alloy in the industry — it can hold the key to future success for many foundries. Its surprising rate of growth will probably continue unchecked as the alloy's versatility finds new applications and new markets.

International Harvester Converts Memphis Foundry to Ductile Iron

LAST MONTH International Harvester Co. began production in its new ductile iron castings foundry in Memphis, Tenn.

This plant, in operation 13 years as a gray iron foundry, took a year to be converted completely to ductile iron production. "The changeover," said Brooks McCormick, executive vice president, "is the culmination of more than a decade of research in ductile iron use by our company."

Termed by IH "the second largest ductile iron foundry in the United States and probably the world," its present daily rate of production is 75 tons with an ultimate daily capacity of more than 200 tons.

The IH foundry is particularly interesting because it shows clearly how a gray iron foundry is readily converted to ductile iron. Here is a description of a part of the IH equipment and facilities.

Melting is done in two unlined water-cooled cupolas. One is a 57-inch unit with melting capacity of 63 to 87 tons per eight-hour shift. The other is a 72-inch cupola which melts 106 to 138 tons per shift.

The cupola melting zone is 12 Well is lined with carbon black. feet high and has no refractory.

The cupola is cooled by an even flow of water (350 gallons per minute) down the exterior of the melting zone. This water is recovered, cooled in a cooling tower, and reused. The cooling permits modification of melting conditions from acid to basic and at any point in between.

Melting conditions are controlled and temperature of the molten metal is increased by a hot blast system that preheats to 600°F the air used for combustion within the cupola. Fuel for heating the air is gas taken from the cupola. A special device controls the amount of moisture in the hot blast air, giving better control of melting conditions and the carbon content and eliminating substantial variables usually encountered in cupola operation. The hot air is blown into the cupolas through water-cooled tuyeres which aim the air directly at the melting zone.

The cupola is charged with steel scrap, least expensive of the charging materials. A small amount of high silicon pig iron is added.

Merry-go-round Charging

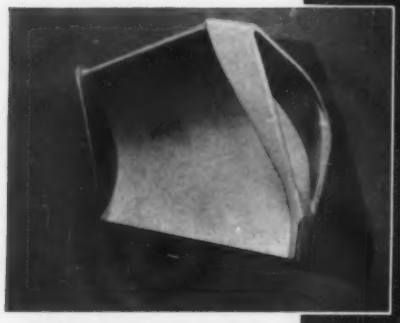
A crane handles charging buckets that automatically drop their load when they enter the top of the cupola. The average charge is 2200 pounds of metal, 300 pounds of coke for fuel, 140 pounds of limestone and 40 pounds of high-grade fluorspar to cleanse the molten iron. The materials are loaded in the charging buckets on a four-stage merry-go-round charging unit. Accurate weighing permits control of quantities within a fraction of a pound on each material.

Slag is carried off in running water that granulates it. Delivered to a hopper by elevator buckets, the slag is then removed daily by truck with no manual handling. The 2800-degree molten iron flows into a six-ton holding ladle in front of the cupola.

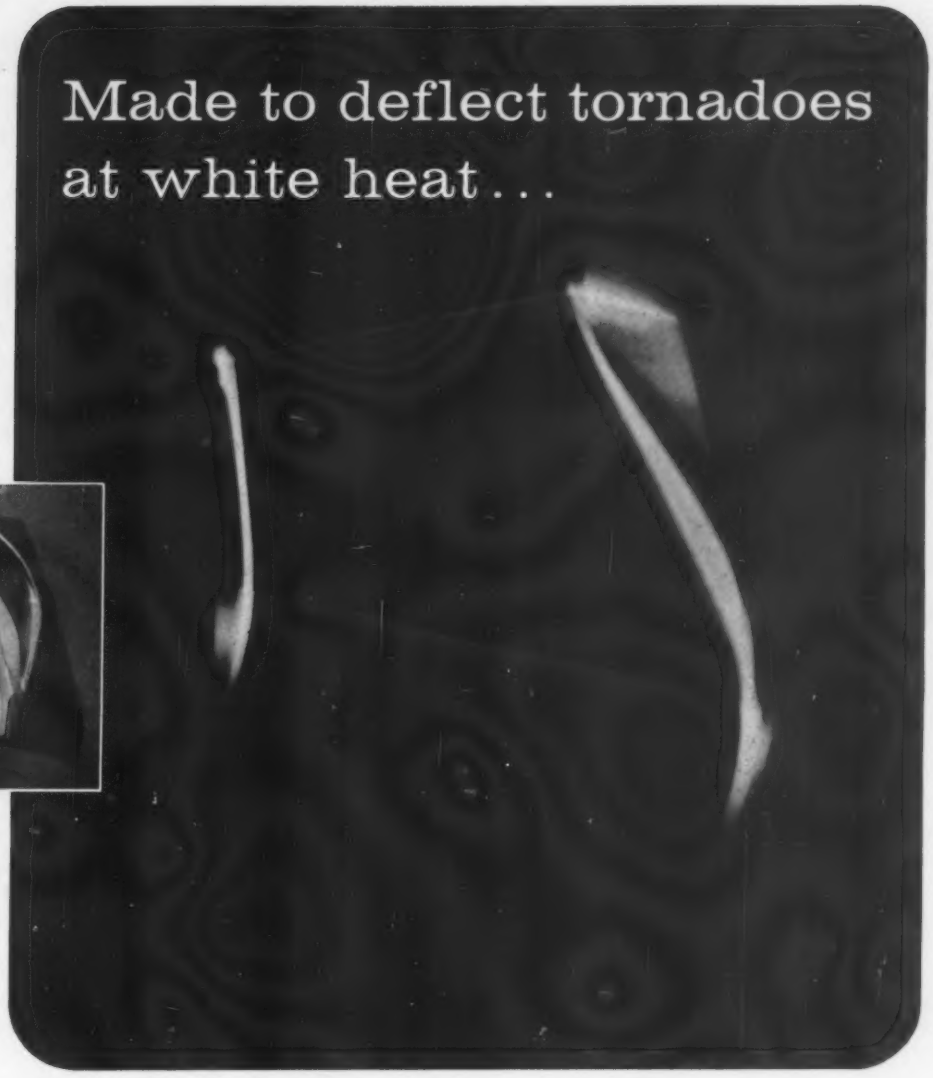
Each cupola is served by a separate treatment unit consisting of car, ladle and scale. The holding ladle is tilted by electric motor to pour 4000 pounds of molten base iron into the treatment ladle. The unit then moves from in front of the holding ladle to a treatment station. A heavy lid lowers to cover the treatment ladle. Attached to the lid is a special plunger that adds 60 pounds of magnesium alloys by submerging it in the molten iron, insuring a better mix of alloy and iron and minimizing the loss of alloys by flotation and burnoff. An automatic timer controls the cycle of the plunger. Scales weigh both iron and alloys to insure proper treatment of specific qualities of iron. Electric ladle trucks take on loads of inoculated iron at the treatment

(Continued on page 58)

Made to deflect tornadoes at white heat . . .



Casting of nozzle guide vane for turbo-jet engine



Radiograph shows casting sound and up to its job

Nozzle guide vanes in turbo-jet engines must withstand fiery blasts — dependably. Austenal Company, division of Howe Sound Company, checks the soundness of each cast vane with radiography

Cobalt base or nickel base high-temperature alloys are required in order to withstand these terrific temperatures. Investment castings are specified because of the alloys that must be used and because the vanes would be almost impossible to forge, machine, or otherwise fabricate, at the cost level of investment castings.

Austenal Company, division of Howe Sound Company, casts these blades by the "lost wax" method. Each one is then radiographed to make sure that no hidden flaw lurks within that could cause failure.

Makers of quality castings, small and large, find radiography invaluable in making sure that only high-quality work is delivered. It is a way reputations are built and new business won.

Radiography can work for you, too. To find out how, talk it over with an x-ray dealer or write us for a Kodak X-ray Technical Representative to call.

New . . . Ready Pack in ROLLS and SHEETS.

Kodak Industrial X-Ray Film, Types AA and M, in 200-ft. rolls (16mm, 35mm, 70mm) and sheets (8 x 10, 10 x 12, 11 x 14, 14 x 17).

- No darkroom loading—film sealed in a light-tight envelope.
- Just place Ready Pack in position and expose.
- Film protected from dust, dirt, light and moisture.
- In the darkroom—remove film from envelope and process.

Kodak
TRADE MARK

EASTMAN KODAK COMPANY
X-ray Sales Division • Rochester 4, N.Y.

Circle No. 153, Pages 145-146

station and deliver it to the pouring stations.

Three types of heat treating —normalizing, two-step normalizing and annealing—produce castings in all three specified grades of nodular iron.

The heat treat department has four new furnaces, all gas-fired, continuous-type units. Capacity of the department is approximately 15,000 tons per year.

A direct-fired furnace is used for normalizing. Two large elevated radiant-tube furnaces with controlled atmosphere are used for two-step normalizing and annealing. A small radiant-tube furnace is used for low volume production items and also for experiments on heat-treat cycles for castings being heat-treated in the large radiant-tube furnaces.

In all three heat-treating processes, castings are heated to 1600°-1650°F and held at that temperature for two hours. In normalizing, they are cooled to a slightly lower uniform temperature and then air-quenched in a soft current of air. In two-step normalizing, they are dropped from 1600-1650°F to 1400-1450°F for three hours and then air-quenched. In annealing, the castings are reduced to 1300-1350°F and held at that temperature for three hours before air-quenching.

Castings are elevated into the radiant-tube furnaces in shallow containers (30"x30"x12"). As three containers enter, three others leave the furnace and dump their hot castings on a vibrating grid under an insulated hood, where they are cooled by air drawn in from outside, blown over the castings, and then exhausted from the building.

So that analyses can be made fast and frequently, a modern fully equipped metallurgical laboratory is located inside the foundry, near the melting cupolas. The laboratory has the latest equipment for chemical, metallurgical and physical testing.

Testing at High Speed

Samples from each load in the treatment ladle receive a prompt microscopic check of its nodule formation. A complete analysis of the base iron is made every hour. Highspeed determiners make carbon and sulphur analyses two or three times an hour. Temperature checks at the cupola are made every few minutes.

A pneumatic tube delivers samples to the laboratory and returns the analyses to the melting area.

An extremely accurate laboratory Brinell machine projects enlargements of metal indentions, insuring more accurate measurements and hardness tests.

Studies of the structure of the iron are made on $12,000 microscope equipped with straight light, polaroid and dark light. This microscope will be used for research and to determine structural trends in the iron.

Castings will be given continuous inspections at each stage of manufacture and a final inspection. Testing methods will include x-ray and sonic test as well as statistical quality control.

THE CONTRIBUTORS
To Market Opportunities

A. P. Alexander
Chief Metallurgist
International Harvester Co.

E. W. Aylward
President
Neenah Foundry Co.

Willis C. Brown
President
Precision Manufacturing Co.

J. W. Bryant
Newbury Manufacturing Co., Inc.

Tom E. Eagan
Chief Research Metallurgist
The Cooper-Bessemer Corp.

D. A. Ferdinandsen
Savannah Machine & Foundry Co.

Lewis W. Greenslade
Superintendent of Foundry and
Sanford Dittmer, Jr.
Manager, Foundry Sales
Brown & Sharpe Mfg. Co.

Warren C. Jeffery
Product Development Manager
McWane Cast Iron Pipe Co.

Russell C. Johnston
Sales Manager
Industrial Division
Crown Iron Works Co.

Harry H. Kessler
President
Meehanite Metal Corp.

C. F. Mally
President
Stuart Foundry Co.

Henry McWane
President
Lynchburg Foundry Co.

Kenneth O'Neal and
Ned Verhage
Clinton Engines Corp.

B. S. Parker
President
The Youngstown Foundry & Machine Co.

Leslie C. Paulsen
Sales Manager
The Electron Corp. Foundry Div.

G. W. Phelps
Otaco Ltd.

Donald J. Reese, Director
Ductile Iron Division
The International Nickel Co., Inc.

J. E. Rehder
Vice President Technology
Canada Iron Foundries, Ltd.

Harold W. Ruf
Vice President
Grede Foundries, Inc.

John Schuyten
Vice President
Vulcan Foundry Co.

Robert S. Thompson
President
The H. P. Deuscher Co.

G. H. Tompkins
Foundry Manager
The Black-Clawson Co.

H. A. Weiner
Apex Foundry Inc.

coke...tested and retested... to give you better melting in your cupola

Coke that gives optimum performance in the cupola doesn't "just happen." It's the result of quality control from mine to cupola—and this includes testing every step of the way.

Every day in every Semet-Solvay coke plant, continuous tests are conducted to determine and control product quality and uniformity: Chemical tests, pyrometric tests, physical tests. Shatter tests, specific gravity tests, porosity tests.

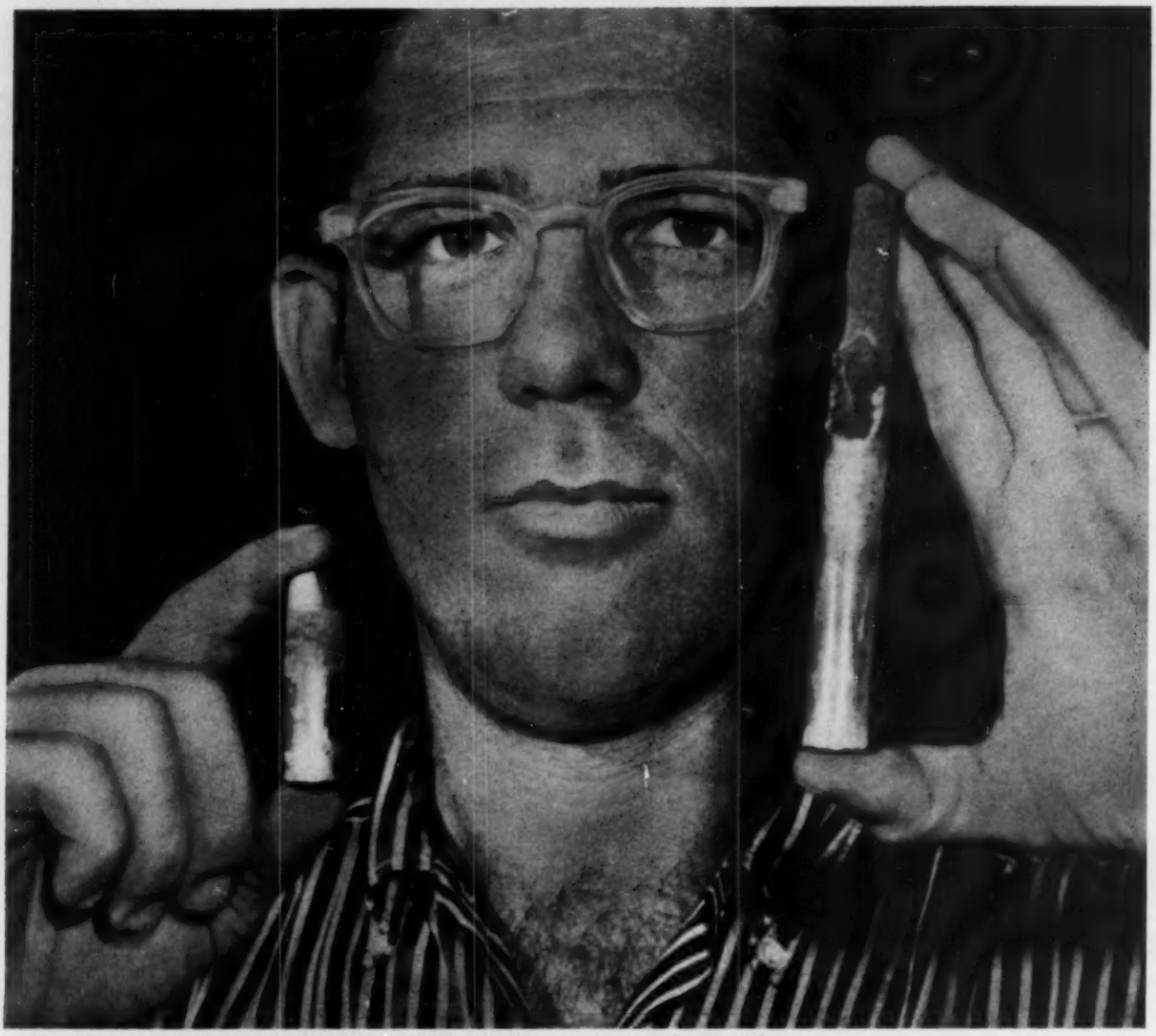
Result: Coke that is low in ash and sulphur, high in carbon, strong and uniform . . . to super-heat and melt your metals in the hottest, fastest, most efficient cupola operation you can possibly have.

For the whole story, write Dept. 613-MCs today for our just-off-the-press brochure, "The Advantages of Using Semet-Solvay Foundry Coke."

SEMET-SOLVAY DIVISION
40 Rector Street, New York 6, N.Y.

Allied Chemical
BASIC TO AMERICA'S PROGRESS

Circle No. 154, Pages 145-148



Short Kostkutter Rod stub at left contrasts strikingly with wasted conventional cutting carbon stub at right—nearly three times as long.

"Speer KOSTKUTTER® RODS save us money three important ways,"

says Floyd Harbin, Cleaning Room Foreman, Commercial Steel Castings Co., Marion, Ohio

Check these very substantial benefits that Commercial Steel Castings Company derives from Speer Kostkutter Rods and ask if you can afford to be without them:

- **Rod savings** of close to 25%—interlocking feature permits joining rod stub to new rod in just a few seconds, drastically cutting stub wastage.
- **Time savings** of 12-18%—rods' interlocking design keeps torch at work more continuously, eliminates time-consuming sleeve-joining methods.
- **Torch life considerably increased** since heat is kept away from the clamp.

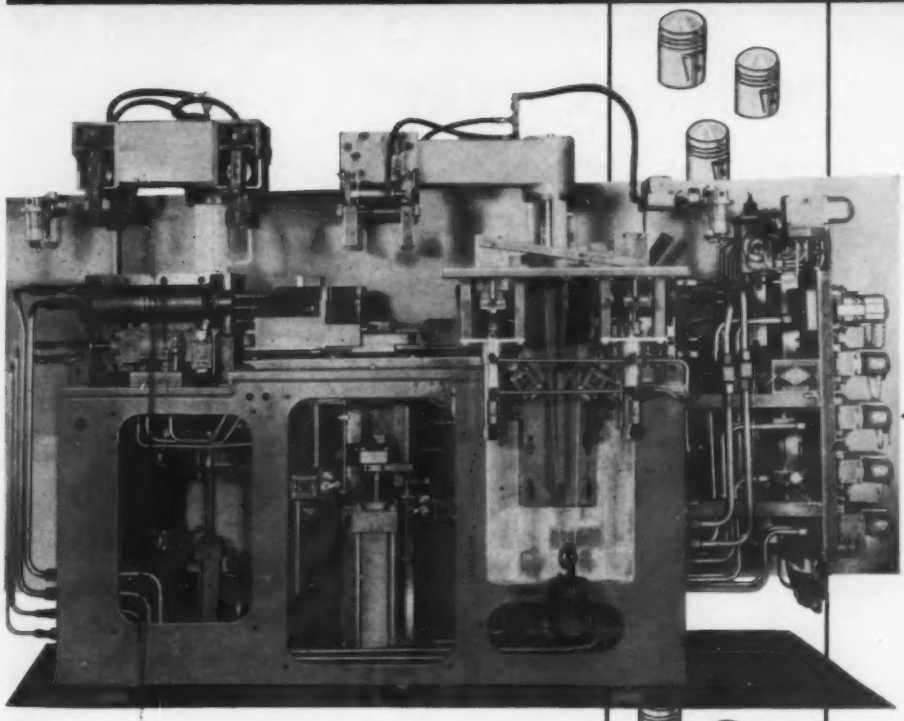
Concerned with getting maximum metal removal for every dollar expended on cutting carbons? Then you'll appreciate the time- and money-saving advantages of Kostkutter Rods. An exclusive product of Speer Carbon Company, they are available in diameters of ½", ⅝", ¾" and 1".

SPEER Carbon Co.
ST. MARYS, Pa.

Circle No. 155, Pages 145-148

almost 600%

increase in output with two units . . . and one operator



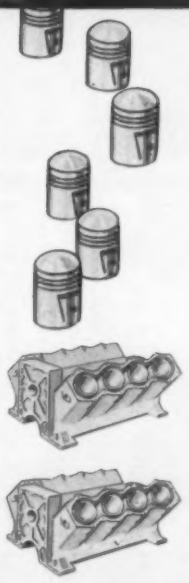
PMD

This Automated Piston Molding Machine is typical of the equipment that has been developed for industry by Permanent Mold Die Company, where designing and building special automated molding equipment is an important function.

This machine incorporates the advantages of metal molds and cores, manual or automatic operation, and adaptability to various sizes of pistons. IT HAS INCREASED THE RATE OF PISTON PRODUCTION ALMOST 600%!

The automatic cycle includes insertion of dimension-control bands into the mold, assembly and disassembly of molds and cores, and transfer of completed pistons to customer's chute or belt conveyor. These PMD machines are designed to operate in groups of two, UTILIZING A SINGLE OPERATOR. The operator can pour at one machine during piston solidification at the other. These machines are also adaptable to automatic ladling. Most of the processes of this machine are hydraulically actuated and all the electric, hydraulic, and pneumatic functions conform to Joint Industry Conference Standards.

The machines developed and built by Permanent Mold Die Co., can produce small parts such as pistons, as well as large automotive aluminum castings. This equipment is developed to **your** specifications, to meet **your** particular needs.



PMD

PMD automated molding equipment offers you a wider production potential at relatively low cost. Investigate its advantages for your operation.

PMD

PERMANENT MOLD DIE COMPANY

2275 E. Nine Mile Rd. • Warren, Michigan • Phone: SLocum 7-8100

Circle No. 61, Pages 145-146

A SURE WAY TO SAVE!

change to

"SUPER-STEEL"

SHOT or GRIT

$165.00

PER TON

TRUCK LOADS

in 50 or 100 lb. bags, steel drums, pallets.

Paying more than $165 for steel abrasives? Why?

Leading foundries, steel mills and metalworking plants* are getting highly efficient and economical cleaning and descaling with "SUPER-STEEL" and are saving many important dollars! You can, too!

Take the first step toward saving—write, wire or phone us collect. We'll rush a trial order, test samples, more information or have our abrasive engineer call on you.

*Names on request.

METAL BLAST, INC.

873 EAST 67th STREET • CLEVELAND 3, OHIO • Phone EXpress 1-4274

ALSO IN Chattanooga • Chicago • Cincinnati • Dayton • Detroit • Elberton, Ga. • Grand Rapids • Greensboro, N. C. Houston • Los Angeles • Louisville • Milwaukee • Minneapolis • New York • Philadelphia • Pittsburgh and St. Louis.

MANUFACTURERS OF TOP QUALITY "SEMI STEEL" SHOT AND GRIT, MALLEABLE AND CHILLED SHOT AND GRIT — AT COMPARABLE SAVINGS

Circle No. 157, Pages 145-146

150 COMPLETE MOLDS PER PAIR EVERY HOUR

Photograph shows BQ Machine in one of the mechanised foundries of Dartmouth Auto Castings Ltd., Smethwick, England.

ON BQ AUTOMATIC MOLDING MACHINES

Agents in U.S.A.: **Stamford Engineering Works, 507 Canal Street, Stamford, Connecticut.**	Maine, Vermont, New Hampshire, New York, Massachusetts, Connecticut, Pennsylvania, New Jersey, Delaware, Maryland, West Virginia, Virginia, North & South Carolina, Georgia, Florida.
American Silica Sand Inc., 402 Central Life Building, Ottawa, Illinois.	Minnesota, Wisconsin, Michigan, Iowa, Missouri, Illinois, Indiana, Ohio, Kentucky, Tennessee, Alabama, California.*
M. A. Bell Co., 217 Lombard Street, St. Louis 2, Missouri.	Nebraska, Colorado, Kansas, Oklahoma, Arkansas, Texas, Louisiana.
Carl F. Miller & Co., 2450 6th Ave., South Seattle 4, Washington.	Washington, Oregon.

* *In California:* **R. K. Unsworth, 2701 Washington Avenue, Redwood City, California.**

For details of straight draw or turnover machines write NOW:

BRITISH MOULDING MACHINE COMPANY LTD

WESTON WORKS • FAVERSHAM • KENT • ENGLAND

AFS New Technology-1961

October Contents

Shell molding operators can cut operating costs with safer, cleaner working conditions. Learn how to determine exhaust requirements and recommended types of equipment. 65

Tilt pouring of aluminum offers manufacturing and quality advantages in long and short job runs. A bright future is predicted for this process. 68

Foundry, machining, and heat treating practices make possible quality aluminum patterns and core boxes which possess light weight, high conductivity, and abrasion resistance. 71

Vacuum and inert atmosphere melting produces alloys not possible with standard processes. Their greatest potential calls for understanding advantages and limitations. 75

What is the outlook for high integrity castings in airframes? Good, say the authors in this candid article pointing out many industry weaknesses. 86

Welding of high strength yellow brass castings cuts scrap losses. In addition, weldability increases design latitude in complex shapes. 89

A new testing method using a dilatometer provides a new tool for revealing the behavior of sands during casting. 96

An AFS progress report summarizes work in attempting to produce compact graphite in the as-cast structure of cast irons. 103

Process quality control integrated with supervision and trouble shooting gives product consistency and customer satisfaction. 110

Kilocurie cobalt sources allow radiographing of heavy section steel thicknesses with minimum of expense. 118

A formula allows foundrymen to determine the amount of heat lost by metal as it passes through a sand runner. Formula also discloses how various designs influence the loss. 119

Elimination of porosity in stainless steel and wash heats, and heats of 100 per cent revert point up possibilities in the vacuum techniques. 127

About The New Technology

Here are 64 more pages of New Technology — selected breakthroughs in the metalcasting field which appear exclusively in MODERN CASTINGS in 1961.

Interpretive summaries of all New Technology for 1961 appeared in the May issue (pages 69 to 84).

These breakthroughs are the most important new technological advances in metalcasting. They were authenticated as new contributions by a 600-man technological committee guided by a member of the editorial and professional staff, S. C. Massari, AFS Technical Director.

DUST AND VAPOR CONTROL FOR SHELL MOLDING OPERATIONS

by Elijah B. Henby

ABSTRACT

Shell molding operations emit dusts and vapors as hazardous as conventional foundry molding practices. A description is given of the hazardous compounds, their origin and general toxic effects. Preparation equipment and its exhaust (usually provided by the manufacturer) is described and illustrated. Methods are shown for determining exhaust requirements to reduce fire or explosion hazards. Suggestions concerning exhaust of the molding, curing, glueing and core-making operations are given. Importance of makeup air and a method for estimating fuel costs are described. Recommendations are made regarding type of dust collectors best suited for shell mold exhaust systems.

INTRODUCTION

The thermosetting resins in shell mixtures have been used for molding purposes for over 40 years. Early shell mixture preparation included the use of dust suppressants, and the odors associated with the process afforded some protection to operators because they could not tolerate severe concentrations. It is no wonder then that the process was generally believed to have no potential hazards. Recent studies[1] by industrial hygienists prove that shell molding is as hazardous as conventional molding practice.

POTENTIAL HAZARDS

An American Foundrymen's Society publication[2] and the studies cited describe the potential hazards, and establish excellent methods and suggestions for controlling the dusts and vapors associated with shell molding. This paper describes:

a. The compounds which are hazardous and their origin.
b. Those operations for which equipment manufacturers usually provide adequate means of exhaust.
c. Reasons for following in-plant ventilation practices established by AFS or as modified by recent experience.
d. Recommended dust collection equipment and disposal of contaminants.

The hazardous (toxic or flammable) compounds involved are given in the table.

The hazards of fire and explosion usually receive immediate attention from insurance underwriters, equipment manufacturers and foundrymen. Figures 1 and 2 illustrate pilot size shell preparation units typical of those widely used for preparation of shell mixtures by many methods, i.e., using powdered, lump or liquid resins and cold, warm or hot preparation. Note that the mixing and material transfer equipment is hooded, enclosed and/or exhausted or ventilated.

Exhaust rates for this preparation equipment are 2.5 to 5 cfm/lb of sand capacity. This exhaust volume prevents escape of dust and vapor into the working area, and keeps the atmosphere inside the mixer less than 25 per cent of the LEL (Lower Explosive Limit) for methanol vapor-air mixtures. These exhaust rates have been thoroughly checked with explosive meter equipment, and with proper equipment operation the methanol-air ratio has never reached the 25 per cent of LEL level. These rates are verified by the dilution formula[3] and by using values for methanol:

$$Q_{LEL} = \frac{387 \times 100 \times C}{\text{Mol Wgt liquid} \times \text{LEL} \times B}$$

where:

Q_{LEL} = Cu ft dilution air required per lb methanol.
C = A safety factor dependent on percentage of LEL.
Mol Wgt = 32 for methanol.
LEL = 6 per cent.
B = A constant accounting for a decreasing LEL at elevated temperatures. B is 1

Toxic or Flammable Compounds

Item	Operation of Origin	Remarks
Silica	Material handling Preparation Shakeout	Silica content, particle size and concentration is similar to conventional sand practice — risk of silicosis is no different.
Resins	Material handling Preparation Molding	Powdered resins present a fire or explosive hazard similar to flour. Some persons subject to dermatitis from contact.
Solvents	Material handling Preparation Mold release Glueing	Methanol vapors are toxic, flammable and explosive. Little information is available regarding hydrolyzable silicones, but methyl, mixed methyl and phenylpolysiloxane types are recommended.
Products of Combustion	Preparation Molding Curing Pouring Shakeout	Reaction gases and vapors resulting from heating resins and solvents. May include formaldehyde (membrane irritant and hardener), phenol, ammonia (asphyxiant), carbon monoxide and dioxide.

E. B. HENBY is with National Dust Collector Corp., Chicago.

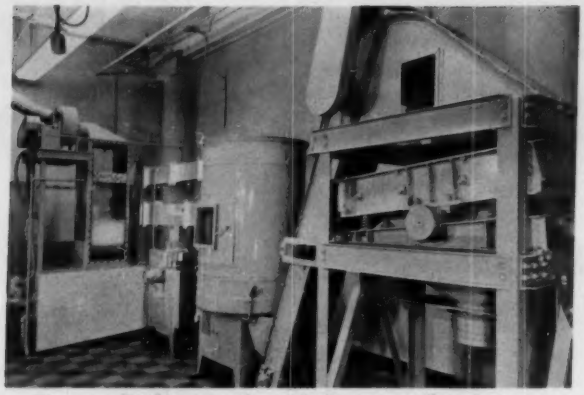


Fig. 1 — Shell preparation unit, heater, muller, elevator and cooler, with all exhausts connected to wet dust collector.

up to 250 F (121 C); B is 0.7 above 250 F (121 C).

Substituting:

$$Q_{LEL} = \frac{387 \times 100 \times 4}{32 \times 6 \times 0.7} = 1{,}150 \text{ cu ft dilution air}$$

required per lb methanol evaporated.

NOTE: Derivation of the figures 387 and 100 which appear in the numerator:

The molecular weight in lb of any gas or vapor occupies 387 cu ft at 70 F and 29.9 in. mercury (Avogardro's Principle). Since the LEL is expressed in per cent (parts per 100) rather than ppm (parts per million as for the MAC), the factor of 1,000,000 becomes 100.

A 1000 lb sand batch in which 3 lb methanol are added and evaporated in 3 min:

Air required for safety:

$$3 \text{ lb methanol} \times \frac{1{,}150 \text{ cu ft}}{\text{lb}} \text{ or } 3{,}450 \text{ cu ft}$$

Air actually supplied:

$$3 \text{ min} \times 1000 \text{ lb sand} \times \frac{2.5 \text{ cu ft}}{\text{lb sand}} \text{ or } 7{,}500 \text{ cu ft}$$

Extensive tests have shown that the dilution to prevent fire or explosion in even an open type mixer is at a satisfactory level; however, the toxicity of methanol makes this type of operation unsafe. Toxicity is measured by maximum acceptable concentration (MAC) in parts per million (ppm) of air. MAC's are based on 8 hr exposure, are reviewed yearly and revised when toxicological data warrants.[3] Use of the appropriate formula illustrates why an open mixer can meet LEL dilution, but is unsatisfactory for toxic reasons:

$$Q_{MAC} = \frac{387 \times 1{,}000{,}000 \times K}{\text{Mol Wgt liquid} \times MAC}$$

where:

Q_{MAC} = Cu ft dilution air per lb methanol.

K = An experience factor dependent on toxicity, uniformity of distribution, dilution, location of exhaust, etc., varies from 3 to 10.

Substituting (using the lowest K factor):

$$Q_{MAC} = \frac{387 \times 1{,}000{,}000 \times 3}{32 \times 200} = 182{,}000 \text{ cu ft}$$

dilution air required per lb methanol evaporated.

Assume as before that 3 lb methanol are evaporated, but the cycle is now at room temperature and takes 10 min:

$$\frac{3 \text{ lb methanol}}{10 \text{ min}} \times \frac{182{,}000 \text{ cu ft}}{\text{lb}} = 54{,}500 \text{ cfm}$$

minimum dilution ventilation required for open mixer to meet MAC – quite an exhaust volume from the corner of a shop having an open mixer.

Features available on some types of preparation units are—an expanded metal hoodtop covered with asbestos paper (in event of an explosion this hoodtop would minimize danger to personnel by serving as a "blow-out" panel) and an exhauster arrangement insuring negative pressure within the mixer hood (a safeguard against toxic vapor leakage into immediate working area).

It is obvious that exhaust of preparation equipment, as provided by most equipment manufacturers, is fully adequate as regards to safety, and is certainly more economical in air handled than attempting dilution ventilation in a working area.

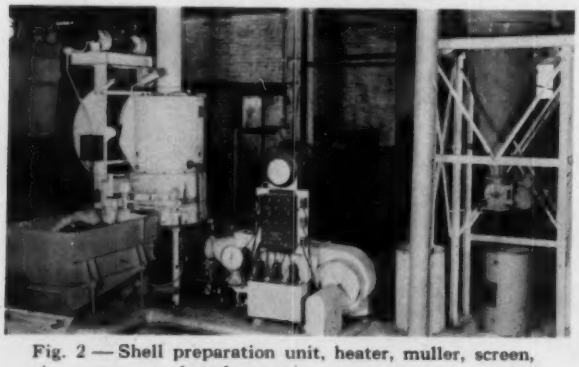


Fig. 2 — Shell preparation unit, heater, muller, screen, air conveyor and cyclone stripper, connected to stacks.

MIXTURE SCREENING AND TRANSFER

Shell mixtures usually require screening and transfer to molding stations. The exhausts recommended by AFS[2] are satisfactory. Equipment manufacturers may provide hoods for exhausting these points of transfer and use such exhaust both for cooling and mixture. As a transfer medium a cyclone collector is properly used to recover the product because it is usable.

Molding, curing, glueing, core-making and shakeouts are hot; therefore decomposition products are evolved, e.g., phenol, formaldehyde, ammonia, methanol and carbon monoxide or dioxide. All are toxic. These operations require hooding in accordance with AFS[2] hood design practice, preferably enclosing or side draft canopy type hoods, the latter especially for operations requiring operator manipulation.[1,3] Volumes exhausted are calculated on basis of 150 cfm/sq ft of hood opening.

Makeup air is essential for proper operation of in-plant exhaust systems and for worker comfort. This

air should move through the working area and thence through area of possible contamination and on into exhaust hoods to sweep contaminants away from workers. Practically, makeup air is desirable and economical. Its use prevents:[3]

a. Upsetting the design of exhaust systems. Insufficient makeup creates higher statics thus lowering exhaust volumes below design values.
b. Back drafts from natural draft units, e.g., furnaces, boilers, ovens, etc., which can contaminate work areas with sulfur dioxide, carbon monoxide, etc., by short circuiting toward exhaust hoods.
c. Cross drafts which interfere with hood exhausts and can dislodge hazardous dusts from building structures.
d. Worker discomfort and the all too common difficulties with hard to open and slamming doors.

Makeup air is far more economical than attempting to maintain working temperatures by unplanned heating of infiltrated air. The cost of heating makeup air can be estimated as shown in the equation (the cost is based on air entering through a tempering unit):

$$C = \frac{A \times B}{D} \times E$$

where:

C = Estimated cost per hour.
A = Btu/hr to heat 1000 cfm outside air.
B = cfm exhausted in thousands.
D = Available Btus/unit of fuel used.
E = Cost of fuel per unit.

Example:

A = Chicago's average Dec.-Feb. temperature is 25 F (−3 C); therefore 47,000 Btu/hr per 1000 cfm are required.[3]
B = Assume exhaust system is designed for 10,000 cfm.
D = Gas is available at 1000 Btu/cu ft; at 75 per cent combustion heating efficiency, we have 750 Btu/cu ft actually available for heating.
E = Cost of gas is $0.10/therm (100,000 Btu) or $0.001/1000 Btu.

Substituting:

$$C = \frac{47{,}000 \times 10}{750} \times \$0.001$$

= $0.63/hr is cost of fuel to heat 10,000 cfm makeup air in Chicago area.

GOOD HOUSEKEEPING

Although the importance of exhaust for control of toxic dusts and vapors has been stressed, housekeeping is important for prevention of fire and/or explosion. Some dusts will escape from various operations, become airborne and come to rest on floors, beams, etc.; therefore all areas must be kept free of heavy dust accumulations.

What should be done with the dusts and vapors removed from the working area? These contaminants should be removed from exhausts by dust and fume collection equipment to avoid air pollution. Much of the contaminant load consists of toxic vapors. Dry bag collectors are suitable for collection of the dusts, but are ineffective for removal of vapors. Fire and explosion hazards are present, and operational difficulties may occur with condensation of vapors from a shell system.

Wet scrubbers, not packed towers which would become quickly plugged with dusts, of the type familiar to foundrymen (orifice, impingement, centrifugal, etc., and having 3 to 6 in. static loss) are best for collection of the mixture of dusts and vapors. The vapors are absorbed by water, provided the scrubber gives good gas-liquid contact. Fire and explosion hazards are minimized by the quenching action in a scrubber. They are excellent as after-cleaners, following a cyclone "stripper" mentioned earlier. Scrubbing liquor can be recycled to avoid continuous contamination of a disposal system.

It is usually necessary that large shell installations investigate disposal methods for scrubbing liquors containing phenols, methanol, etc. Phenolics can be destroyed by oxidation with chlorine, chlorine dioxide, ozone or permanganate or absorbed on activated carbon or bituminous coal. However, this waste treatment is beyond the scope of this paper.

As a rule the emission of phenol or formaldehyde from a scrubber is not disagreeable, but the odors of these compounds are so strong that the minutest trace may be objectionable to some people outside a plant even though the concentration is not toxic. It may be necessary to introduce a masking agent (in aerosol form) into the exhaust stack. This is an economical remedy.

CONCLUSION

In-plant control of dusts and vapors originating from shell molding operations is necessary because of their toxic and flammable nature. Preparation equipment is available with integral hood and exhaust systems to keep equipment interiors well below LEL's. The standards and principles for in-plant exhaust established by AFS are adequate, and should be followed in planning exhaust from molding, curing, glueing and pouring operations. Makeup air is economical. For the Chicago area, during average winter weather, the cost of gas fuel is approximately $0.63/hr for heating 10,000 cfm of outside air to room temperature. Wet collectors are recommended for collection of the dusts and vapors involved and, in case of odors from shell molding noticed outside the plant, a masking agent is available which can be introduced into the exhaust stack.

ACKNOWLEDGMENT

The author is grateful to National Engineering Co., Chicago, for permission to use Fig. 1; and to the Beardsley & Piper Div., Pettibone-Mulliken Corp., Chicago, for permission to use Fig. 2.

REFERENCES

1. G. E. Tubich, I. H. Davis, and B. D. Bloomfield, "Health studies of Shell Molding," *Foundry*, p. 164 (March 1961).
2. "ENGINEERING MANUAL FOR CONTROL OF IN-PLANT ENVIRONMENT IN FOUNDRIES." American Foundrymen's Society, Des Plaines, Ill. (1956).
3. *Industrial Ventilation*, American Conference of Governmental Industrial Hygienists Committee on Industrial Ventilation, Lansing, Mich. (1960).

TILT POURING PERMANENT MOLD ALUMINUM CASTINGS

by G. W. Stahl

ABSTRACT

An investigation to determine relative merits of the tilt pouring technique, as opposed to simple vertical gating of permanent mold castings, was initiated. Some of the factors considered are soundness of castings, appearance, production rates and relative cost of castings and molds. The study indicates definite advantages in quality of castings as well as in costs. Conclusions point up the fact that the process may have more advantages in some shapes of parts than in others.

INTRODUCTION

All foundrymen are aware of the tremendous increase in the use of aluminum alloy castings in almost all fields in recent years. Much of this increase is in castings which must be sound to withstand air or hydraulic pressures, or must have high mechanical strength or must eventually be polished to a high finish. The permanent mold process is of course well adapted to producing castings of this type. However one of the problems facing all permanent mold foundrymen is turbulence, or the introduction of air into the metal during pouring operation.

There has been a great amount of work done on designing of gating to help eliminate this problem. Most permanent mold foundries have developed their own pet variations of these developments and many are quite effective. Unfortunately, this gating usually involves extra labor in producing mold, extra metal in gates and much extra time in experimental work on each new job.

The purpose of this investigation is to determine if comparatively simple, foolproof gating could be used to produce sound castings by the tilt pouring technique. To this end then it was necessary to use a casting and conventional gating system, which definitely created turbulence and then apply tilt pouring and evaluate results. Although soundness, or the elimination of turbulence, was the primary objective, it was found that other advantages were also apparent.

EQUIPMENT AND METHODS

The part selected was a planer base casting 18 x 23 in. in size having a depth of 2½-in. This casting, without gating, is shown in Fig. 1. The mold for this part was produced by machining from a cast iron casting made in green sand. Gating was machined from the solid. Vertical channels were cut ½-in. deep and ¾-in. wide. Metal was introduced into the cavity through ribbon gates 0.080 in. thick for the full length of the part. The riser at top was made ½-in. thick and 1¼-in. wide with a connecting ribbon 0.120 in. thick. Pouring basins were added to two vertical channels at top of mold to be used in tilt pouring.

The casting with gating attached is shown in Fig. 2. Total weight of mold complete with ejection and 18 x 24 in. mount plates was approximately 425 lb.

G. W. STAHL is with Stahl Specialty Co., Kingsville, Mo.

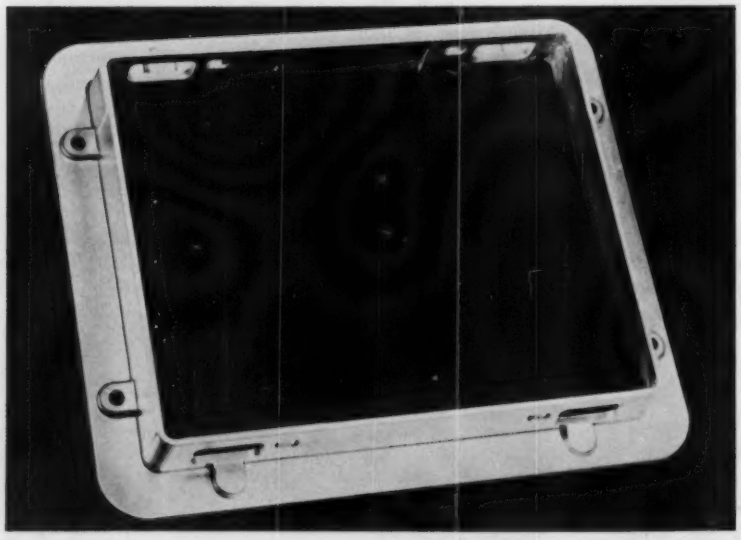


Fig. 1 — Planer base casting 18 x 23 in. with a depth of 2½-in. and a weight of 7 lb.

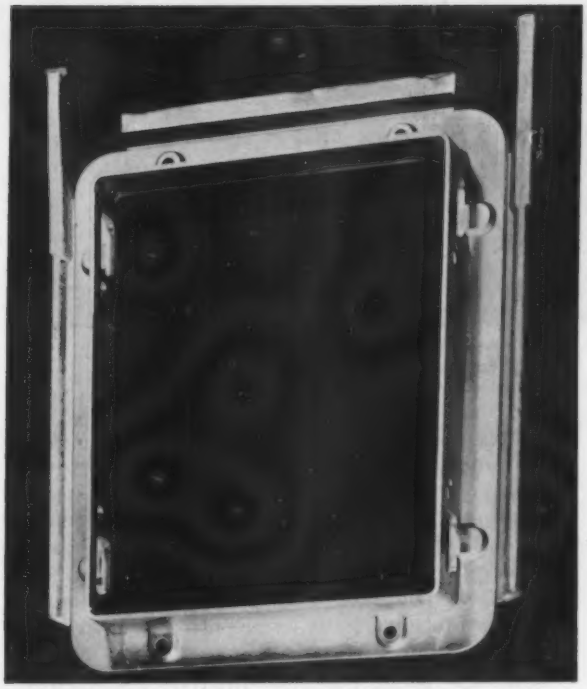


Fig. 2 — Planer base casting complete with simple vertical gating.

The mold was mounted in a standard permanent mold operating machine built to accept standard mount plates. This machine, with mold mounted in place, is shown in Fig. 3, while Fig. 4 shows machine in position for filling pouring wells for tilt pouring. The machine is equipped with a 4 in. diameter hydraulic cylinder for clamping mold and a 2 in. diameter cylinder for tilting. This unit is actuated with a hydraulic unit which furnishes hydraulic power, controls time cycle and controls speed.

The power unit is adapted for automatic operation of each cylinder independent of the other. With the power unit developing 1000 psi, the mold operating machine develops a clamping pressure of 12,000 lb. With the timer and speed control on the power unit, it was possible to control rate of tilt and also time of opening of mold and ejection of castings.

Heating the Mold

The mold was heated to 350 F (176 C) and coated in conventional manner, using a vermiculite base coating on all surfaces with a graphite overspray on cores. Mold was reheated to 800 F (427 C) before mounting in machine. Metal used was commercial A-108 melted in a double chamber reverberatory furnace and held at 1400 F (760 C) in dip out well. Twelve castings were poured by alternately using straight and tilt pouring in order to equalize heat of mold and to allow operators experience in pouring, as well as to determine proper speed for automatic tilt pouring.

After producing these 12 castings mold temperature had leveled off at 725 F (385 C), and it was determined that a pouring time of 25 sec was quite satisfactory for tilt pouring. The test run then was made by producing 25 acceptable castings by each method using same metal of the same temperature in the same mold and with the same cycle.

RESULTS

Cost of Castings

The first apparent difference noticed was that in tilt pouring only one operator was required, since it was only necessary to fill pouring wells for each cycle. These wells could be filled by pouring rapidly. However, with vertical pouring it was necessary to use two operators, since the vertical channels were 20 in. apart, and it was necessary to pour quite slowly. It would have been possible to design gating system so that one man could pour both sides, but this would have complicated the mold considerably.

In order to get 25 acceptable castings by tilt pouring it was necessary to pour only 26 pieces. This would indicate a scrap rate of 4 per cent. With vertical pouring using two men, it was necessary to pour 32 pieces. The scrap rate then from manual pouring was 22.9 per cent. These scrap pieces were due to misruns because of variation of rate of hand pouring. Since overall cycle was 2 min 30 sec for both

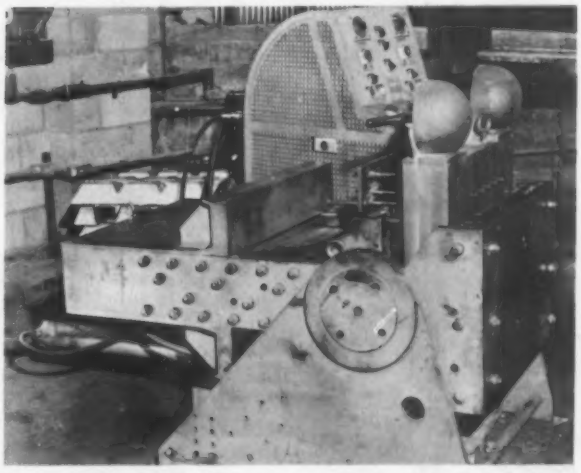


Fig. 3 — Mold for planer base mounted in operating machine with power unit ready for operation.

Fig. 4 — Same machine and mold as in Fig. 3 with machine in position for filling pouring wells.

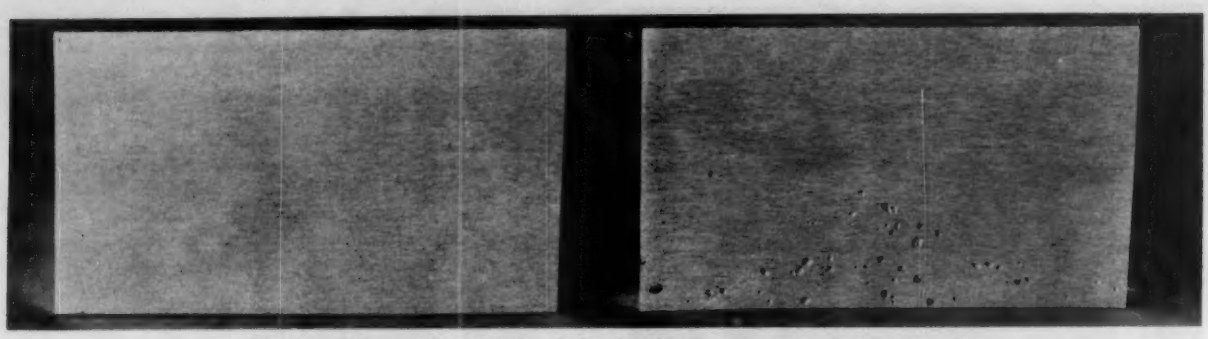


Fig. 5 — *left* — section showing lack of voids in same area in tilt poured casting; *right* — section showing typical voids in one area of vertical poured casting. Both sections were ground to expose structure 0.035 in. below surface.

methods, one man produced 25 castings in 1.08 hr, whereas two men required 1.33 hr, or 2.66 man hr, to produce same number of castings.

In order to check castings for soundness, a number of castings from each group were sectioned and ground on 180 grit belt to expose any voids. On the right in Fig. 5 is a section taken from a typical casting poured vertically. Note the large number of voids. Some of these measured as much as 0.080 in. diameter. On the left in Fig. 5 is a section taken from same area in typical casting made by tilt pouring. This section shows no voids.

Obviously, the vertical poured casting did not show this amount of voids in all areas. The area selected was on a horizontal plane, which normally would show effects of turbulence. However, the section from tilt poured casting was from same area, in fact the tilt poured castings showed absence of voids throughout entire castings.

Flash

Examination of castings showed one other distinct advantage on the side of tilt pouring. This advantage was in the better control of flash on cored holes. On the right in Fig. 6 is a section taken from a typical vertical gated casting, while illustration on left in Fig. 6 is an identical section taken from typical tilt poured casting. Note that flash on vertical poured casting projected into cored hole, in fact this flash measured more than $\frac{5}{16}$-in. in width in some cases. Flash on tilt poured castings measured less than 0.050 in. Please bear in mind these castings were produced in same mold under same conditions except for method of pouring.

It was readily apparent that tilt poured castings were quite uniform in color and finish, whereas the vertical poured castings showed a tendency toward variation in brightness, and even showed tendency toward shrinkage in certain areas. This variation on vertical poured parts was apparently due to changes in hand pouring rate. The tilt poured castings were all poured automatically, which allowed cavity to be filled uniformly each time.

Although there was less difference between the castings in finish than in some other factors, the tilt poured castings showed a better overall surface finish than did the vertical poured castings. In fact the vertical poured castings showed definite roughness in areas of flow and in areas which had voids below the surface.

CONCLUSIONS

It is apparent that on this part, tilt pouring will give turbulence free castings by using the simplest of gating. Also these better, turbulence free castings can be produced faster and at less cost than by vertical pouring with the same gating.

This study was made on only one particular design of casting. The advantages of tilt pouring may be greater or less on other shapes.

The author realizes that the concept of tilting a permanent mold to pour is not new. However, it is felt that not enough study has been devoted to the technique to realize its full potential. The author believes that unless automatic control is used on the pouring much of the advantage may be lost. Also a study of shapes of pouring basins is indicated, since it is possible to vary the rate of pour from bottom to top of mold by varying shape of basin.

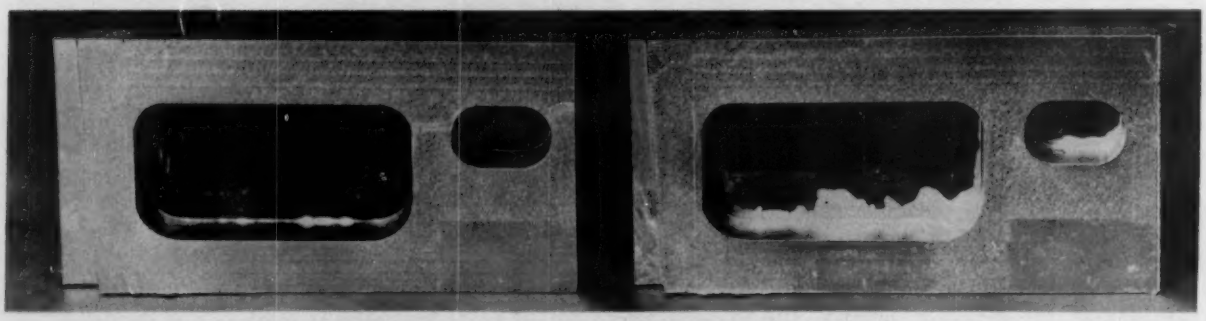


Fig. 6 — *left* — section showing amount of flash in cored holes in tilt poured casting; *right* — section showing amount of flash in cored holes in vertical poured casting.

ALUMINUM PATTERN CASTINGS

by W. E. Sicha

ABSTRACT

Aluminum patterns and core boxes have the advantages of light weight, good machinability, high conductivity of heat and generally satisfactory resistance to abrasion. Problems have been encountered occasionally in obtaining aluminum pattern castings of satisfactory metallurgical quality. The quality requirements vary for different types of pattern equipment. Foundry practices for attainment of the desired quality are discussed in considering each pattern type, shown in the illustrations.

MATCHPLATES

Practically all of the aluminum matchplates, or cope and drag plates, with integrally cast patterns, now are pressure cast in plaster molds. This casting process, also used to produce core boxes, has been described in several technical papers[1,2,3,4,5] and depicted in movies.[6,7]

An important feature of the process is the economic advantage gained in making plates incorporating several identical patterns. Relatively inexpensive transfer techniques can be used to produce many patterns from a single master pattern.

Application of pressure in casting affords accurate reproduction of fine details in the pattern. Use of plaster molds provides smooth pattern surfaces and permits maintenance of close dimensional tolerances. It is essential that the master pattern be produced with a slightly higher level of smoothness and dimensional accuracy than is required in the cast pattern plate. This can be accomplished most effectively by using a completely machined metal master pattern.

Since the desired pattern shape is provided by the plaster casting process, little machining is performed on pattern plates. The major metallurgical requirement, therefore, is that the metal be sound on the surface and to a depth of about $\frac{1}{16}$-in. A moderate amount of internal gas porosity or shrinkage will not impair the serviceability of the matchplate.

W. E. SICHA is Chief, Castings and Forgings Div., Alcoa Rsch. Laboratories, Cleveland.

Melts of aluminum alloys for casting matchplates do not require thorough fluxing for removal of hydrogen, if the foundry practices produce sound metal at and near the surface of the pattern. Alloys with good casting characteristics, which include the aluminum-silicon and aluminum-silicon-copper alloys, are equally suitable for pressure cast matchplates and core boxes. Heat treatment is not necessary except for pattern equipment that will be operated at an elevated temperature. This subject will be discussed later.

PATTERNS AND CORE BOXES

Aluminum patterns, other than matchplates, generally are produced by sand casting. A few patterns are fabricated using wrought aluminum products, and material selection can be based on readily available mechanical property data.

Practically all master patterns and models require extensive machining, as do many sand cast patterns and core boxes. Most of the quality problems with cast pattern equipment are encountered when machining operations are necessary. They include porosity, warpage and inadequate surface smoothness.

Porosity

The three principal types of porosity are shrinkage, cope gas holes and gas porosity. The presence of shrinkage is evidence that satisfactory gating and feeding was not provided in producing the casting. This type of defect should not be encountered often, because foundrymen recognize the necessity to compensate for the reduction in volume during solidification of aluminum alloy castings. Many technical articles have been published on gating and feeding, providing ample information on techniques for producing shrinkage-free castings.[8]

The occurrence of localized gas holes at cope surfaces also results from unsuitable gating practices. A gating system that causes turbulence of the molten

Fig. 1 — Drag and cope sides of a pressure cast aluminum matchplate. Minor surface polishing has been performed.

metal while it is being introduced into the mold or the casting cavity can trap large gas bubbles that rise to cope surfaces. Oxide inclusions usually are associated with these sub-surface cope gas holes. Practices that exclude this type of defect are thorough skimming of the molten metal in the ladle or crucible prior to pouring, keeping the lip of the ladle close to the top of the sprue when pouring, use of small diameter, thin rectangular or tapered sprues and devising a gating system that introduces metal into the casting cavity with a minimum of turbulence.

Generally and uniformly distributed porosity is caused by precipitation of hydrogen bubbles during solidification of the casting. Corrective measures entail prevention of hydrogen absorption by the molten aluminum alloy or removal of the dissolved hydrogen before pouring the metal. Oily, dirty or corroded metal will introduce hydrogen into the melt. Heating the melt to temperatures above 1400 F (760 C), or holding the metal molten for extended time periods, usually will increase the hydrogen content. Melting by directing a flame onto the metal also will introduce hydrogen.

Even though care is exercised to avoid introduction of hydrogen, removal operations may be required. Hydrogen removal can be accomplished by bubbling chlorine or nitrogen gas through the melt. Some salt fluxes also are effective in removing hydrogen. The extent of the treatment required

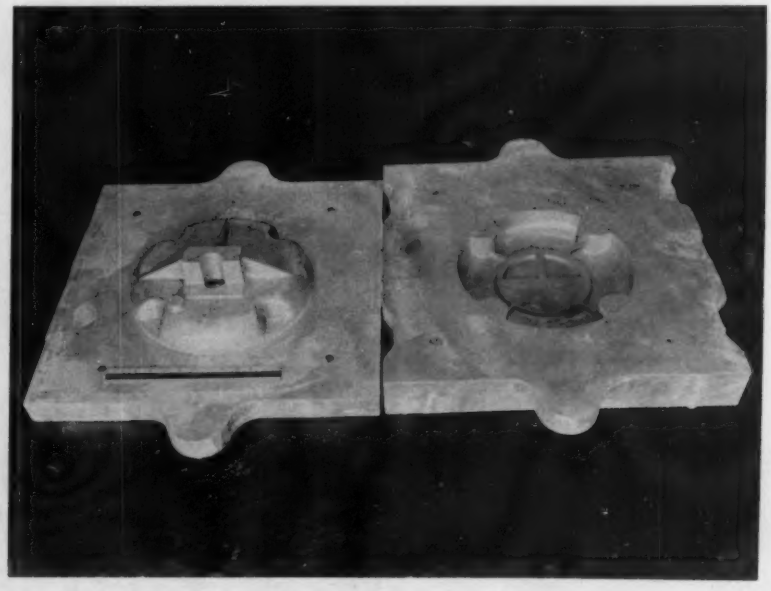


Fig. 2 — Pressure cast cope and drag aluminum patterns. Backs are contoured to reduce weight.

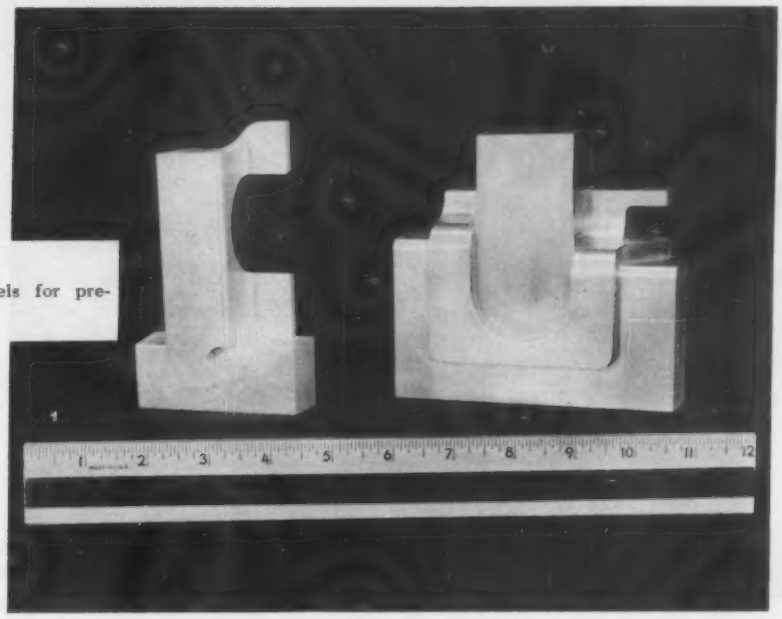


Fig. 3 — Fully machined aluminum models for precision equipment production.

will depend on the hydrogen content of the melt and can be determined by experience, using metal of consistent quality.

Another factor contributing to porosity in castings is the practice of using fine, natural mold sands with low permeability and high moisture contents to obtain smooth cast surfaces. This type of molding sand can cause formation of cope gas holes or gas porosity in castings, and can also be responsible for blow defects. Selection of a synthetic molding sand with an AFS permeability of 15 to 25, and tempering the sand with the lowest practical quantity of water, will provide adequate surface smoothness and avoid introduction of gas into the castings.

Warpage

The most common causes for warpage in machining large pattern castings of aluminum alloys are distortion in clamping, inadequate coolant or dull tools. Machinists experienced in handling ferrous castings may apply excessive force in clamping or chucking aluminum castings. The elastically deformed aluminum casting then changes shape after machining when the clamping forces are removed. Use of insufficient coolant or dull tools can allow overheating, which will cause expansion and distortion of the clamped casting during machining. The casting dimensions and shape then will change while cooling to room temperature.

Some pattern castings have been solution heat treated, quenched and aged to increase hardness and improve machinability. A heat treatment of this type may introduce residual stresses, which can be redistributed during machining and cause warpage. The need for such heat treatment and the attendant risk of warpage in machining can be avoided by adoption of the subsequently recommended pattern alloy.

Surface Smoothness

The smoothness of the machined surfaces will depend largely on the tools and techniques employed. Good machining practices are beyond the scope of this discussion. However, the machinability of pattern castings will be influenced by the alloy composition and heat treatment. Subsequent comments on these two factors will show their effect on machinability and other characteristics.

ALLOY SELECTION

Some problems that have been encountered with pattern castings of unsatisfactory quality undoubtedly were caused by using alloys with poor casting characteristics. For example, resmelted aluminum sheet scrap is not of suitable composition for producing castings.

A variety of aluminum-silicon and aluminum-copper-silicon alloys have been used successfully in making pattern castings. An investigation of several of these compositions showed that most of them exhibited good feeding characteristics. The experimental castings were free of internal gross shrinkage although relatively few risers were used. However, the best reproduction of the mold cavity shape was obtained with an aluminum alloy containing 7 per cent copper and 5 per cent silicon. This alloy displayed the least surface shrinkage of the depression type in test castings that had inadequate risers.

Significant advantages should be gained by using an alloy especially suitable for the purpose in producing pattern castings. High quality casting can be made more consistently with pattern alloy ingot of controlled and uniform composition. A good pattern alloy composition is aluminum-7 per cent copper-

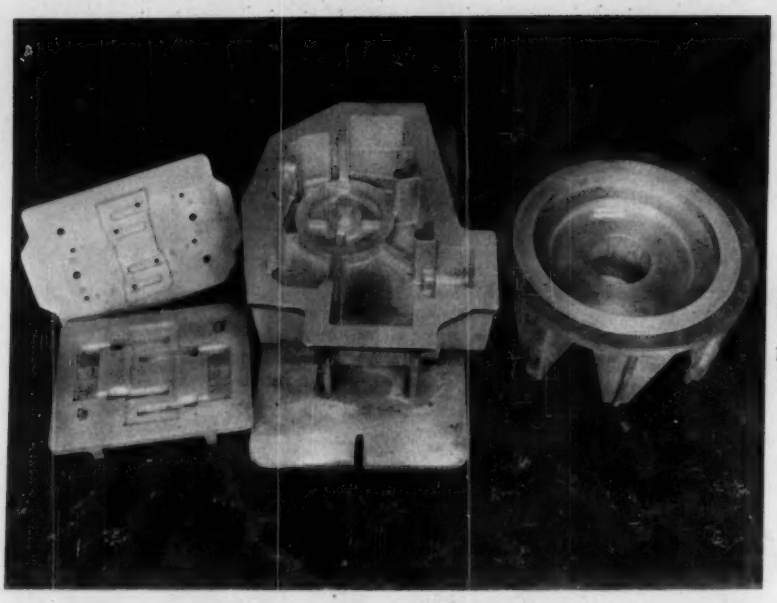


Fig. 4 — Cast and machined aluminum core boxes. *Left* — Box for core blowing, *Middle* — Box for shell core production and *Right* — Box for hand rammed core — steel faced — 15¾-in. O.D.

5 per cent silicon-0.15 per cent titanium with low impurity limits.

Castings of this alloy exhibit generally good machining characteristics, without heat treatment. It is necessary occasionally to make repairs on pattern castings, and established soldering or welding practices are suitable for castings of this alloy.

SHELL MOLDING PATTERN EQUIPMENT

Production experience has demonstrated that aluminum alloy patterns and core boxes frequently are suitable for shell molding, although cast iron pattern equipment generally has been preferred.[9] The preceding remarks on techniques to produce patterns and core boxes of good quality are equally applicable for shell molding pattern equipment of aluminum. Since shell molding patterns and core boxes operate at elevated temperature, the subsequently described aging treatment always should be employed to insure dimensional stability in service.

HEAT TREATMENT

Many cast patterns and core boxes are not and do not need to be heat treated. Heat treatment has been used to increase hardness which improved machinability, but this should be unnecessary with the recommended alloy.

Patterns and core boxes that will be operated at elevated temperatures should be heat treated if it is important to retain close dimensional tolerances. Most aluminum alloys are subject to dimensional growth of about 0.001 in./in. when heated to temperatures of 300 F (149 C) or higher for extended periods of time. This dimensional change during use can be avoided by heating the castings at 400 F (204 C) for 4 to 6 hr before machining. Core driers also would benefit by application of this aging treatment prior to final scraping and fitting. An alternative and suitable annealing treatment for core driers consists of heating at 600 F (316 C) for 2 to 4 hr and cooling in the furnace.

SUMMARY

Aluminum pattern equipment affords significant advantages for the users. Several factors have been discussed which influence the quality of pattern castings. It is hoped that the recommendations on foundry practices, alloy selection and heat treatment will help producers to supply pattern shops with aluminum castings of high quality.

REFERENCES

1. K. A. Miericke, "Technique of Producing Pressure Cast Aluminum Matchplates," AFS TRANSACTIONS, *vol. 58*, p. 198 (1950).
2. R. F. Dalton, "Production Patterns and the Matchplate," AFS TRANSACTIONS, *vol. 58*, p. 699 (1950).
3. H. J. Jacobson, "New Methods in Metal Patternmaking," AFS TRANSACTIONS, *vol. 60*, p. 529 (1952).
4. Edward Magder, "Pressure Cast Aluminum Alloy Pattern Match-Plate," *Canadian Metals*, p. 39 (Oct. 1955).
5. Jean Duport and Pierre Rigant, "Alloys for Patterns and Match Plates; Precautions for Avoidance of Cavities," *Fonderie*, p. 1838 (Nov. 1949).
6. Movie, "Making a Match Plate with USG Formulated Metal Casting Plaster," U. S. Gypsum Co., Chicago.
7. Movie, "Pressure Cast Match Plates," Scientific Cast Products Co., Cleveland.
8. "Symposium on Principles of Gating," American Foundrymen's Society (1951).
9. B. N. Ames, "A Survey of the Shell Molding Method of Casting Production," AFS TRANSACTIONS, *vol. 61*, p. 7 (1953).

SPECIALTY MELTING AS A SERVICE FUNCTION IN A RESEARCH LABORATORY

by W. F. Moore

ABSTRACT

Equipment for vacuum induction melting, consumable and inert electrode arc melting, atomic hydrogen melting and zone melting both horizontally and by the floating zone method are described. Applications of this equipment in the performance of service melting of a wide variety of specialty materials for use in a research laboratory is discussed. In this discussion methods are brought out for determining which of the many types of raw materials, crucibles and melting practices is most suitable to the particular job.

INTRODUCTION

There have been for years many methods for melting and alloying metals. The demand for specific materials for more highly specialized uses has forced the improvement of old melting methods and the development of new and better methods for making these materials. It is only natural that this should result in the formation of more and more facilities devoted entirely to specialty melting.

It is extremely important in a research laboratory that each scientist be able to obtain experimental quantities of metals and alloys that he may be working on, without actually building his own equipment to produce them. It is characteristic that the requirements of this type of customer can be satisfied only by special melting procedures.

One of the prime functions of a specialty melting unit in a research laboratory is a service function, and consists of supplying these scientists with samples of any and all types of metals and alloys in forms most useful to them. It is expected that these samples will be of the highest quality possible.

It is not the purpose of this paper to describe the methods for melting any specific metal or alloy but rather to describe some of the equipment in a specialty melting laboratory, and to describe how this equipment can be used to best advantage when practically every job differs from every other job.

W. F. MOORE is with Met. and Ceramics Rsch. Dept., General Electric Co., Schenectady, N.Y.

In order to fulfill its mission successfully, a specialty melting unit must be well equipped. While it is necessary to have equipment for all of the conventional types of melting, this paper will be limited to a discussion of those types of melting equipment requiring vacuum, inert, or special atmospheres, which have been used most extensively in the author's company's research laboratory.

The advantages inherent in the vacuum melting processes make it imperative that any specialty melting facility be well supplied with this type of equipment. Some of these advantages are:

1. Melting in the absence of oxygen and nitrogen permits a much fuller utilization of alloying elements.
2. The presence of fewer oxides and nitrides means fewer inclusions and, hence, improved properties.
3. Larger quantities of more reactive elements can be used, thus making possible new and improved alloys.
4. Casting in vacuum permits much higher casting yields with fewer cold shuts.
5. Deoxidation with hydrogen or carbon can be carried out with the consequent formation of gaseous deoxidation products, which can be continuously removed from the vicinity of the molten bath without forming slag.
6. Volatile impurities are removed by evaporation from the melt.
7. Hydrogen is completely removed.

MELTING PROCESSES AND EQUIPMENT

The methods of melting used extensively in carrying out service melting within the author's company's research laboratory are a) vacuum induction melting, b) cold crucible arc melting, (consumable electrode vacuum arc melting and inert arc electrode melting), c) atomic hydrogen melting and d) zone melting.

Each process along with examples of specific equipment will be described briefly and their use discussed.

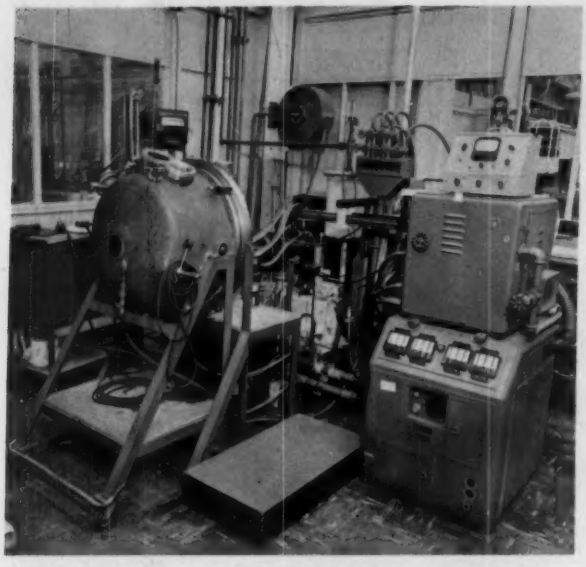


Fig. 1 — Vacuum induction melting furnace (0-2 lb capacity).

Vacuum Induction Melting

The process of vacuum induction melting can be described simply as a charge of metal melted in an induction furnace within an evacuated chamber. The charge is exposed to a refining cycle, determined by the type of material being melted, late additions are made to the heat and the metal is poured within the chamber either in vacuum or in a predetermined atmosphere.

Vacuum induction furnaces are equipped with the necessary gadgetry for performing all of the operations required during the melting cycle. Two separate addition hopper systems are required, one for adding to the original cold charge and one for making late additions to the melt. These can be replenished through air locks. Manual stirring of the melt or breaking of bridges can be easily accomplished. Temperatures can be measured either optically or by immersion thermocouple. Samples can be dipped from the melt and removed from the chamber through air locks.

Inert or deoxidizing gases can be admitted to the chamber. Hot toppings of ingots can be accomplished by means of an electric arc or by electrically heated ceramic sleeves. Shape castings can be made by pouring into ceramic type molds, which have been completely outgassed prior to pour.

There are two types of materials usually made in the vacuum induction furnace. First are those that can be made by conventional air melting methods. In this case the improvements can be attributed to the vacuum melting process, per se. These materials may contain reactive elements in quantities which make air melting a borderline process, or they may be more ordinary materials whose properties are sufficiently improved by vacuum melting to warrant the extra cost involved.

Second are those that must be vacuum melted because of composition. In this case the improvements are largely due to new alloy compositions, containing fairly large quantities of reactive materials such as titanium, aluminum or zirconium, which can be made successfully only by a vacuum melting process. In either case the quantity of reactive elements that can be melted is limited by their reaction with the crucible material, whether it is of the ceramic oxide type or graphite. The materials that can be vacuum induction melted are also limited to those whose melting points are lower than the temperature at which these same crucibles become unstable.

Vacuum Induction Equipment

Four vacuum induction melting furnaces have been of great use in the specialty melting facility. All of these furnaces permit the same kinds of manipulations. The capacities of these furnaces and melting pressures are shown in Table 1. Photographs of some of these furnaces are shown in Figs. 1 through 4. The 10-30 lb furnace chamber contains a centrifugal casting machine with a 40 in. diameter turntable rotating in a horizontal plane.

TABLE 1 — VACUUM INDUCTION FURNACES

Capacity, lb	Melting Pressure, Microns Hg
100-450	10-35
10-30	10-35
5-50	<1
0-2	<1

Cold Crucible Arc Melting

This type of melting is carried out either by consumable electrode vacuum arc melting or by inert electrode arc melting. In the consumable method, the material to be melted is formed into an electrode. In addition, a small quantity of the material to be melted is placed in the bottom of

Fig. 2 — Vacuum induction melting furnace (0-2 lb capacity).

a cylindrical shaped water cooled copper mold. Crucible and electrode are in high vacuum. An arc is established between the end of the electrode and the starting material in the crucible.

As the material melts off the end of the electrode and drips into the crucible, the electrode is fed downward continuously until it is completely consumed. The heat generated by the arc also maintains a shallow pool of molten metal in the top of the ingot as the ingot is progressively built up from the bottom of the crucible. Degasification of the metal and vaporization of volatile impurities occurs as the metal droplets fall through the high vacuum. Because the molten pool is always quite shallow, the problem of segregation normally encountered in ingot casting is kept to a minimum.

On the other hand, because the metal is maintained in the molten state for such a short period of time, it is sometimes not possible to accomplish as much refining as is desired. Alloys as well as pure metals can be melted in this way by forming the electrodes from blended or pre-alloyed powders or by fabricating composite electrodes from the necessary alloying ingredients. Electrodes of the required composition may also be melted and cast by some other melting process such as vacuum induction melting. Carbon deoxidation may be accomplished by incorporating a predetermined quantity of carbon in the preformed electrode.

In the inert electrode method, the material to be melted is placed in the crucible and the arc is formed between this material and a water cooled tungsten electrode. Additional material may be fed into the crucible to build up the length of the ingot. This method has some disadvantages. There is always the possibility of contamination of the melt by tungsten. This is likely to happen if any of the charge splatters on the tungsten electrode and forms a lower melting constituent than the tungsten itself. This process is also carried out in an inert atmosphere such as argon rather than in vacuum, so that no significant purification takes place.

Both of these methods, of course, eliminate the problem of crucible reaction which is encountered in induction melting. As a result it is possible to melt the more reactive materials such as titanium and zirconium without danger of contamination. Because of the high temperatures attainable in the arc, it is also possible to melt the more refractory materials such as tungsten, molybdenum, tantalum, and columbium. Most of these not only have high melting points but are highly reactive as well.

While it is possible to pour a casting from this type of furnace it is not easily done, and in general this type of melting is limited to buttons and ingot shapes.

Cold Crucible Arc Melting Equipment

The cold crucible arc melting facilities in the company's research laboratory consist of equipment for making both ingots and buttons by consumable electrode vacuum arc melting and by inert arc electrode melting.

There are in operation three principal furnaces,

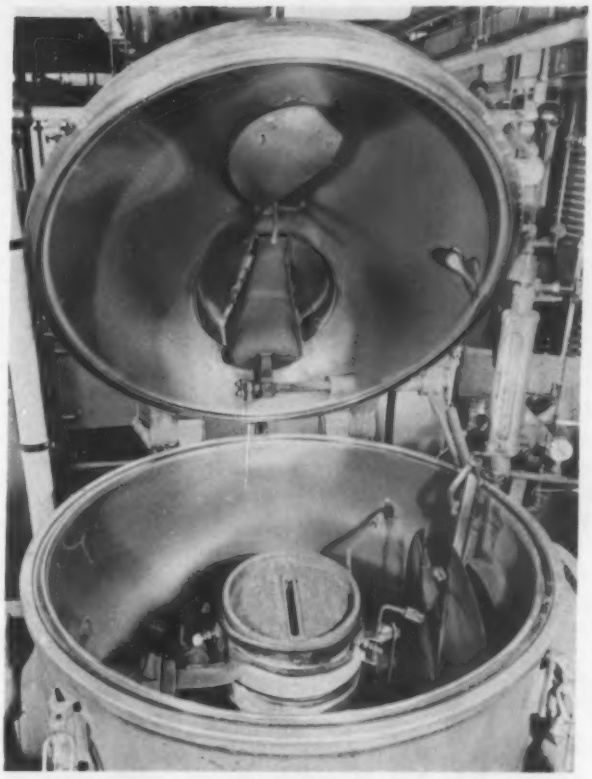


Fig. 3 — Vacuum induction melting furnace (5-50 lb capacity).

one consumable electrode vacuum arc melting furnace capable of making up to an 8 in. diameter ingot, one multi-hearth inert arc electrode furnace containing nine hearths and making use of a thoriated tungsten electrode, and one six-hearth furnace which can be used either as a consumable or an inert electrode furnace. The nine-hearth furnace is illustrated in Fig. 5.

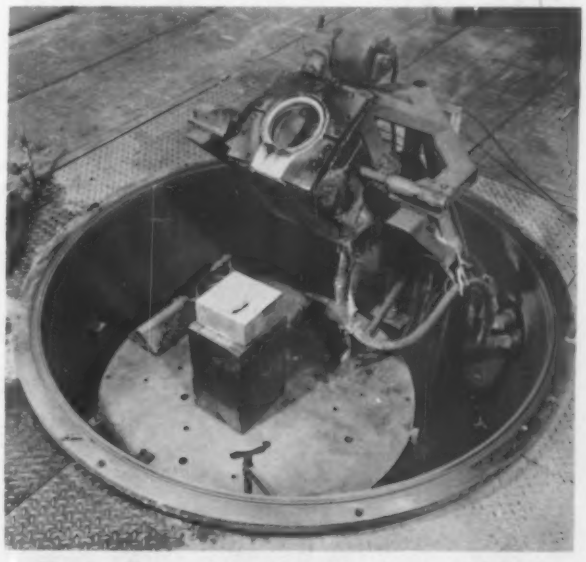


Fig. 4 — Vacuum induction melting furnace (10-30 lb capacity).

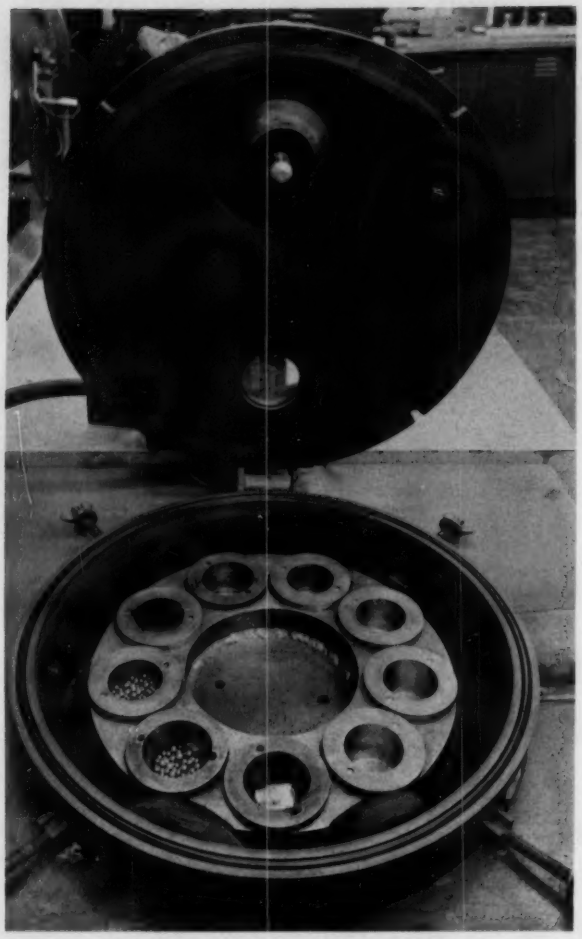


Fig. 5 — Multi-hearth inert arc melting furnace.

Atomic Hydrogen Melting

High temperatures can be reached when atomic hydrogen recombines to form molecular hydrogen. Advantage is taken of this in the atomic hydrogen welding process. It also provides an excellent tool for melting metals and alloys, and comes equipped with its own built-in deoxidizer in the form of hydrogen.

Atomic Hydrogen Melting Equipment

Atomic hydrogen melting in the laboratory is possible on 0-20 gram samples in the furnace illustrated in Fig. 6. In this furnace the ingredients of the melt are placed on a copper hearth. Making use of an atomic hydrogen arc welder, an arc is formed between two tungsten electrodes located above the charge. Hydrogen is admitted to the chamber through orifices around the periphery of the tungsten electrodes. The hydrogen passes through the arc and is dissociated.

It recombines in the vicinity of the metal charge with the evolution of sufficient heat to form a molten bath. This furnace is particularly useful in making small heats where raw material is expensive or not available in large quantities.

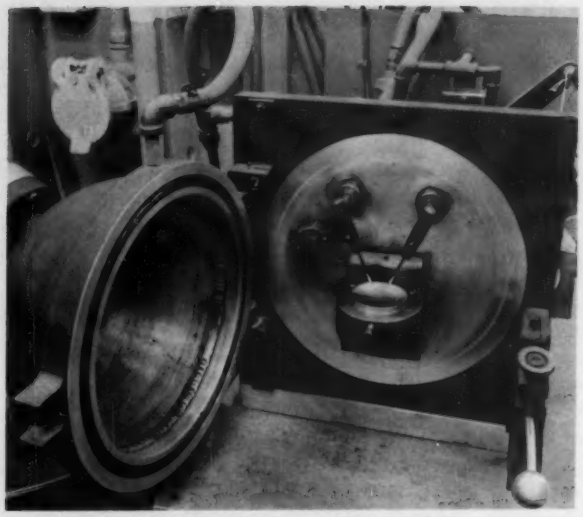


Fig. 6 — Atomic hydrogen melting furnace.

Zone Melting

Zone refining consists of traversing a narrow molten zone of metal slowly from one end of a bar to the other end. At the melting interface, solid metal is melted and added to the molten zone. At the freezing interface, if an impurity lowers the melting point of the base material its concentration in the solid will be less than in the liquid, and hence it will be rejected to the liquid and will accumulate there. If the impurity raises the melting point of the base material its concentration in the solid will be greater than in the liquid, and hence it will freeze out of the liquid.

In this manner some impurities are moved with the molten zone to the end of the bar, and others are left behind as the metal freezes behind the molten zone. Repeated passes of the molten zone through the bar in the same direction will further refine the material until a section somewhere near the center of the bar will be extremely pure. Most impurities will be concentrated at the finish end of the bar with some at the starting end.

Materials refined in this manner reach purity levels which might be measured in parts per billion rather than the usual parts per million, if it were possible to measure them. However, it is often necessary to employ physical measurements such as resistivity as a measure of the purity, because of the inadequacy of the usual chemical or spectrographic methods at these low impurity levels.

Materials which are not contaminated by contact with some crucible material may be zoned horizontally, while contained in a boat. Those which will react with crucible materials may be zoned vertically, without benefit of container, assuming that conditions of surface tension, density of material and any levitating forces that might be applied, are favorable. Obviously this is a slow process and consequently a costly one. Unless there is a need for extreme purity that cannot be obtained in any other manner, this process is to be avoided.

Zone leveling is a term applied to a zone melting technique which almost completely eliminates segregation due to the change in composition of a melt as it freezes. There are a number of different techniques by which this may be accomplished. However, the simplest method is to make several fairly rapid molten zone passes through a charge in each direction.

Zone melting may be accomplished by induction melting, electron beam melting, resistance melting or arc melting. The type material which is to be refined will to a large extent determine the type of equipment needed. For example, it is difficult to melt the highly refractory metals by induction means, so it is necessary to melt these materials by electron beam or arc melting. On the other hand, electron beam melting requires a fairly high vacuum, and this would not be suitable for some high vapor pressure materials.

Induction melting depends upon the material itself being a conductor for its heating ability, but melting in a resistance type furnace does not. On the other hand, induction melting provides a beneficial stirring action to the melt which resistance heating does not. Induction melting also provides some levitating action, which aids considerably in maintaining a floating molten zone without benefit of container.

Zone Melting Equipment

Two pieces of equipment are available in the laboratory for zone melting. Both are powered by a single 450 kc, 25 kw electronic induction heater. Horizontal melting in a crucible or boat is accomplished by passing a quartz tube containing the boat through a fixed induction coil, using a lathe bed and appropriate gears and pulleys as a means of controlling travel speed.

Vertical (floating zone) melting equipment consists of a fixed coil (usually single turn) with a means of passing a bar through the coil vertically. The bar, coil and necessary clamps and chucks are enclosed in a pyrex bell jar. Both pieces of equipment can be pumped to a pressure of 10^{-6} of mercury and operated either in vacuum or inert or deoxidizing atmosphere.

The zone refining equipment is illustrated in Figs. 7 and 8.

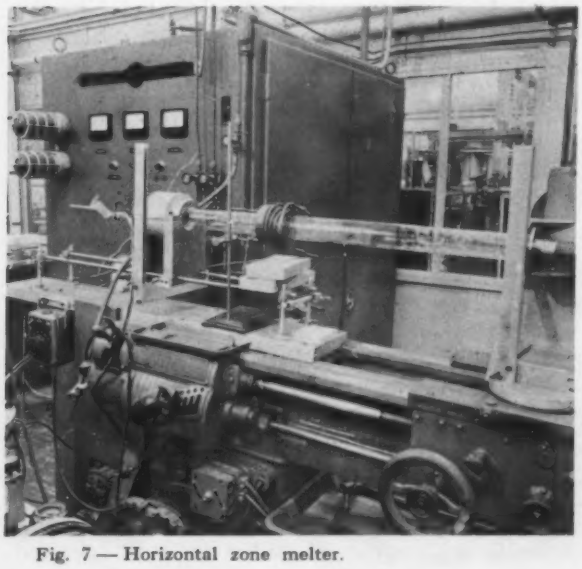


Fig. 7 — Horizontal zone melter.

MELTING OPERATIONS

How to Choose a Melting Process

Why is it necessary to have a variety of types of melting equipment? Each type of melting has its own advantages and disadvantages compared to each other type. Some melting processes are capable of attaining higher temperatures than others, some can be used with more reactive metals than others, some are limited in the size and shape of product that can be made, some are limited more than others in the amount of purification that can be accomplished and some are inherently too expensive for the average job.

It certainly is not always possible to find the perfect melting process for each individual melting problem that arises. Compromises must be made.

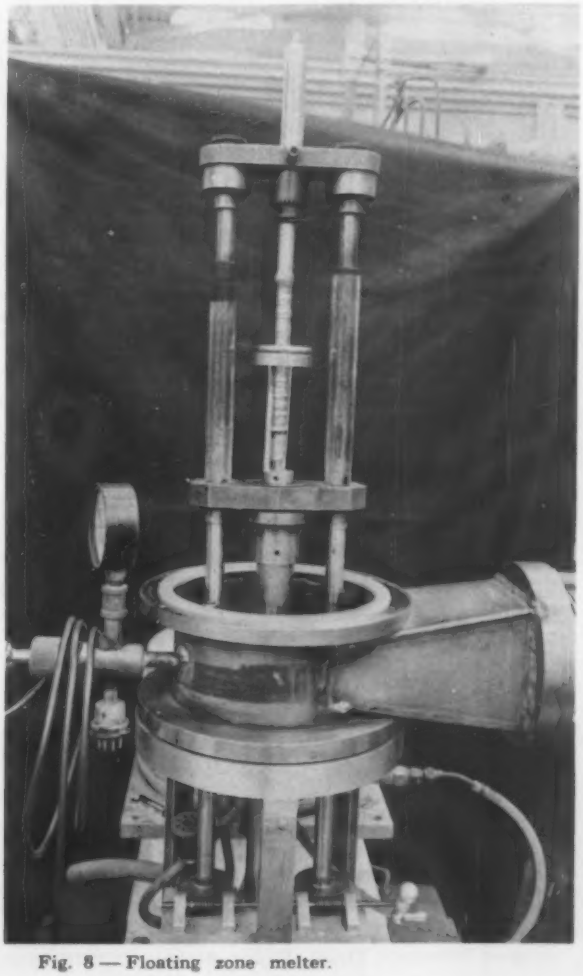


Fig. 8 — Floating zone melter.

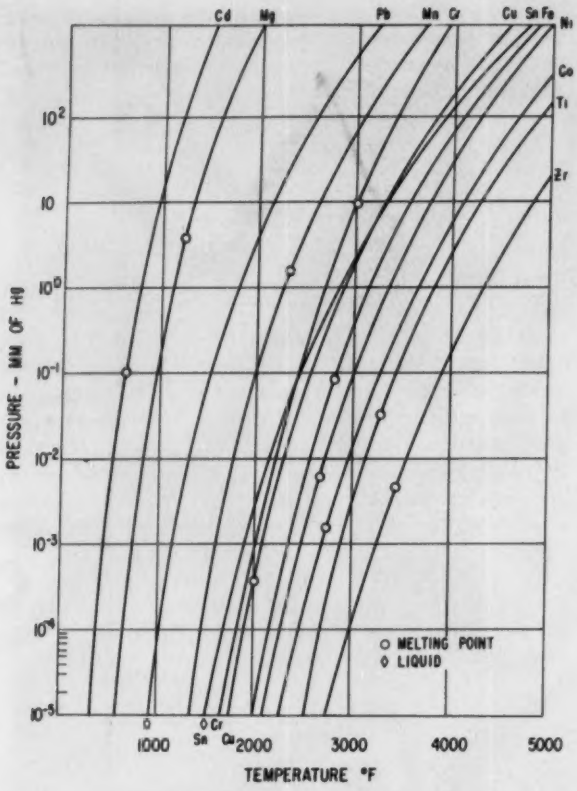


Fig. 9 — Curves of vapor pressure as a function of temperature for some metals.

Questions to Be Answered

In order to determine how a particular metal or alloy is to be processed, a number of questions must first be answered:

1. Is the material a pure metal or an alloy? If an alloy, is phase diagram information available?
2. What is the melting point of the metal or alloy and of each constituent?
3. What is the vapor pressure of each constituent?
4. How reactive is each constituent of the alloy?
5. What purity is desired? How much purification must be accomplished in the melting operation?
6. Is high vacuum desirable or necessary?
7. Are there large differences in density in the alloying ingredients?
8. In what form are the raw materials available?
9. What purity raw materials are available?
10. What shape product is desired?
11. Is slow cooling or chill casting required?

Tools

Some of these questions are answered by the customer. For the answers to others, it is necessary to have available some basic tools. These should include:

Phase Diagram Information. An extensive collection of phase diagrams is invaluable in determining melting point data, solubility data, presence of compounds, eutectics, etc.

Vapor Pressure Data. Vapor pressure versus temperature data for all metals is necessary to determine what degree of vacuum can be utilized in each particular application. It is possible that some impurities, by virtue of vapor pressures higher than the base materials, may be removed from the alloy without loss of base metal at pressures intermediate between the vapor pressure of the base material and the impurity. On the other hand, if melting is done at too low a pressure, it is possible to concentrate low vapor pressure impurities while evaporating base metals. Figure 9 is a curve of vapor pressure versus temperature for a number of metals.

Thermodynamic Data. Thermodynamic data on formation and dissociation of oxides, nitrides and hydrides of metals is invaluable in determining temperatures and pressures at which reactions will proceed. Figure 10 shows the standard free energies of formation of some metal oxides as a function of temperature.[1] Superimposed on this chart are isobars of the reaction of carbon with oxygen as a function of temperature. This is a particularly useful tool in the specialty melting area. It enables a prediction to be made whether crucible reaction will be a limiting factor in the melting of a particular metal or alloy.

It aids in deciding whether deoxidation is necessary and in picking the most effective deoxidation technique. For example, in using this diagram, if a line is drawn from the *O* index at the left of the figure to intersect the line representing the FeO heat of formation at 3000 F (1650 C), the extension of this line will intersect the Po_2 scale at a value of 10^{-6} mm of mercury, indicating that FeO will be dissociated under these conditions of temperature and pressure. This reaction does not help much in an iron alloy because iron itself vaporizes at approximately 300 microns of mercury at this temperature.

Thus too much iron would be lost by vaporization if the heat were to be made at a low enough pressure to dissociate the FeO. Obviously then, in order to produce an iron alloy with low oxygen content something more than low pressure is necessary. Some form of deoxidation is needed. If a line is drawn from the *C* index at the left of the diagram to intersect the FeO heat of formation line at 3000 F (1650 C), the extension of this line intersects the CO/CO_2 Ratio scale at a value of 7/1, indicating that FeO will be reduced by carbon at 3000 F (1650 C) in an atmosphere with the CO/CO_2 ratio greater than 7/1.

Similarly, using the *H* index and the H_2/H_2O Ratio scale, we find that FeO will be reduced at 3000 F (1650 C) in an atmosphere with the H_2/H_2O ratio greater than 1/1. Therefore, either carbon or hydrogen can be used for deoxidation.

It should be remembered in using this diagram that no indication of rates of reaction is given.

Raw Material File. A complete up-to-date file on available sources of raw materials including purity and price must be maintained. There is usually a choice of raw materials available for most jobs. Purities vary from the ferroalloy types to ultra high purity zone refined materials. Prices vary from cents/lb to hundreds of dollars/lb. It is often nec-

essary to compromise on purity for the sake of economy. It is always necessary to use common sense in choosing the purity of raw materials.

In vacuum melting gases are removed from the melt. If the raw materials are extremely high in gas content, the process of their removal may be quite violent. Gas content is therefore an important factor in the choice of raw materials. In considering purity of raw materials we must also keep the application in mind. What might be considered high purity in one application would be impure in another. Using silicon as an example, there are various grades of ferrosilicon which are available.

A 98 per cent silicon at a cost of 29 cents/lb is

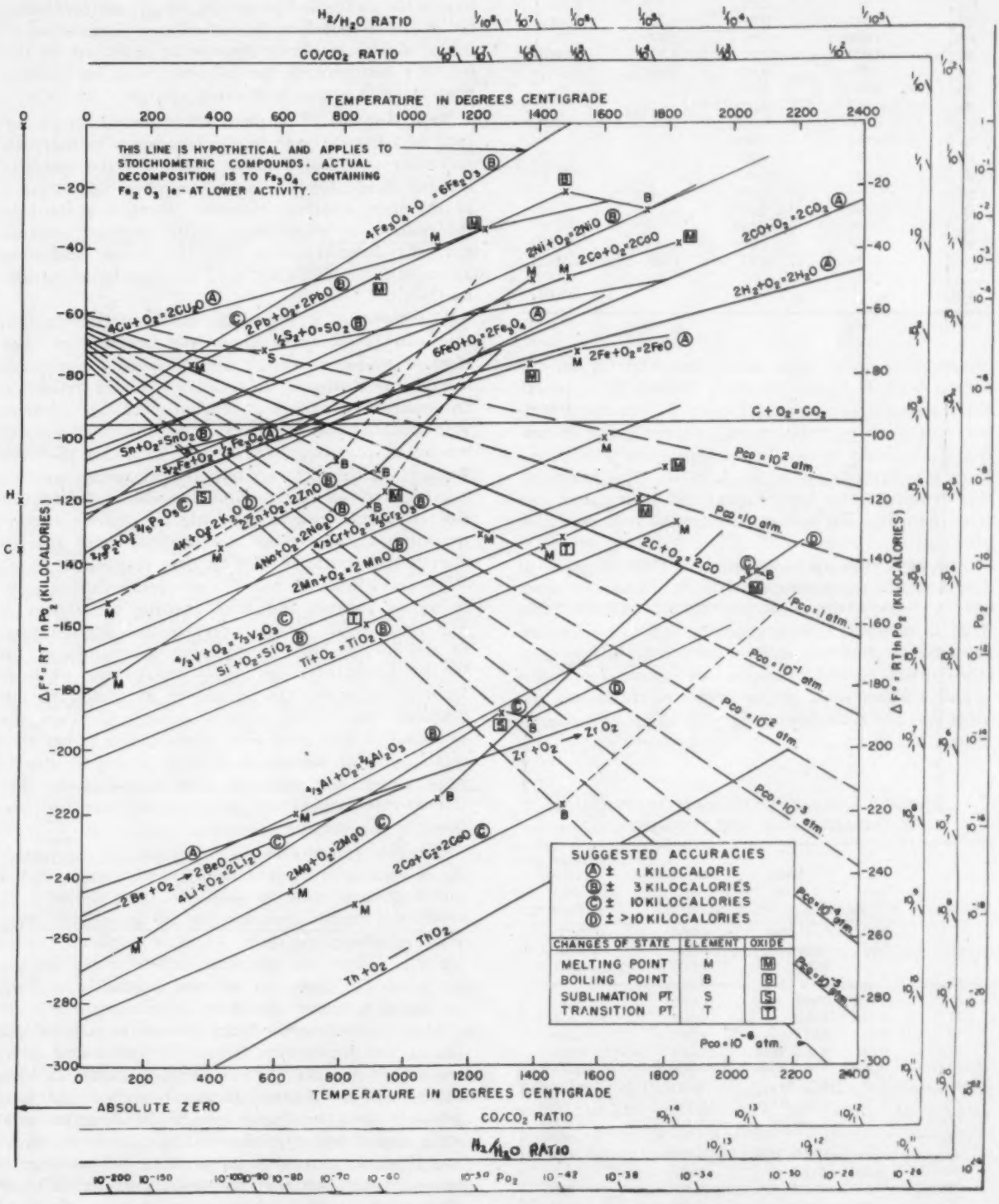

TEMPERATURE IN DEGREES CENTIGRADE
THIS LINE IS HYPOTHETICAL AND APPLIES TO STOICHIOMETRIC COMPOUNDS. ACTUAL DECOMPOSITION IS TO Fe_3O_4 CONTAINING Fe_2O_3 IN SOLUTION AT LOWER ACTIVITY.
$\Delta F^\circ = RT \ln Po_2$ (KILOCALORIES)
H_2/H_2O RATIO
CO/CO_2 RATIO
$4Fe_3O_4 + O_2 = 6Fe_2O_3$
$4Cu + O_2 = 2Cu_2O$
$2Pb + O_2 = 2PbO$
$\frac{1}{2}S_2 + O_2 = SO_2$
$2Ni + O_2 = 2NiO$
$2Co + O_2 = 2CoO$
$6FeO + O_2 = 2Fe_3O_4$
$2Fe + O_2 = 2FeO$
$2CO + O_2 = 2CO_2$
$2H_2 + O_2 = 2H_2O$
$C + O_2 = CO_2$
$Sn + O_2 = SnO_2$
$\frac{2}{3}Fe + O_2 = \frac{1}{3}Fe_2O_3$
$\frac{2}{3}P_2 + O_2 = \frac{1}{3}P_2O_5$
$4K + O_2 = 2K_2O$
$2Zn + O_2 = 2ZnO$
$4Na + O_2 = 2Na_2O$
$\frac{4}{3}Cr + O_2 = \frac{2}{3}Cr_2O_3$
$2Mn + O_2 = 2MnO$
$2C + O_2 = 2CO$
$\frac{4}{3}V + O_2 = \frac{2}{3}V_2O_3$
$Si + O_2 = SiO_2$
$Ti + O_2 = TiO_2$
$Zr + O_2 = ZrO_2$
$\frac{4}{3}Al + O_2 = \frac{2}{3}Al_2O_3$
$2Be + O_2 = 2BeO$
$4Li + O_2 = 2Li_2O$
$2Mg + O_2 = 2MgO$
$2Ca + O_2 = 2CaO$
$Th + O_2 = ThO_2$
$Pco = 10^2$ atm.
$Pco = 10$ atm.
$Pco = 1$ atm.
$Pco = 10^{-1}$ atm.
$Pco = 10^{-2}$ atm.
$Pco = 10^{-3}$ atm.
$Pco = 10^{-4}$ atm.
$Pco = 10^{-5}$ atm.
$Pco = 10^{-6}$ atm.
SUGGESTED ACCURACIES
Ⓐ ± 1 KILOCALORIE
Ⓑ ± 3 KILOCALORIES
Ⓒ ± 10 KILOCALORIES
Ⓓ ± >10 KILOCALORIES
CHANGES OF STATE | ELEMENT | OXIDE
MELTING POINT | M | M
BOILING POINT | B | B
SUBLIMATION PT. | S | S
TRANSITION PT. | T | T
ABSOLUTE ZERO
TEMPERATURE IN DEGREES CENTIGRADE
CO/CO_2 RATIO
H_2/H_2O RATIO
Po_2

Fig. 10 — The standard free energy of formation of many metal oxides as a function of temperature.

TABLE 2 — SOME CHROMIUM RAW MATERIALS AVAILABLE FOR MELTING STOCK

Element	Elect. Chromium Metal, Regular $1.16/lb	Elect. Chromium Metal, Vac. Grade $1.19/lb	Elect. Chromium Metal, Grade A $28.00/lb	Iodide Chromium, $100.00/lb
Cr	99.85	99.35	99.95	99.997
Fe	0.13	0.30	0.009	0.0002
C	0.01	0.05	0.006	0.001
O	0.45	0.04	0.008	0.0008
Si	0.004	0.04	0.009	
Al	0.002	0.05		0.0001
S	0.025	0.01	0.004	
Mn	0.002	0.01		
Pb	0.002	<0.001		
Cu	0.006	0.003		0.0001
Ni	<0.001	<0.001		
Co	<0.001	<0.001		
B	<0.001	<0.001		
Sn	<0.001	<0.001		
Bi	<0.001	<0.001		
Sb	<0.001	<0.001		
H	0.008	0.001	0.0003	0.00008
N	0.035	0.01	0.007	0.0003
P	0.002			0.0003
Mg				0.0001

considered a good high purity material for an air melted heat. If higher purity is desired in a special application, it is necessary to pay $17/lb for a 99.9 per cent pure material. A still higher grade of purity is available in smaller quantities in a densified form of solar cell grade for $100/lb. The purity of this material is no longer measured in terms of per cent impurity, but rather in units of resistivity (3-5 ohm-cm).

The next step up in purity is a $300/lb grade of densified silicon whose resistivity is about 100 ohm-cm. To carry this example to its extreme, this $300/lb material is only good enough to be the raw material in further purification for transistor uses. Two other typical examples are shown in Tables 2 and 3 where some of the grades of chromium and iron that are available, along with their approximate prices, are listed.

TABLE 3 — SOME IRON RAW MATERIALS AVAILABLE FOR MELTING STOCK

Element	Ingot Iron, $.07/lb	Elect. Iron, $.29/lb	Elect. Iron, $1.65/lb	Spectrographic Grade Iron, $130.00/lb
C	0.02	0.01 Max.	0.004	0.03
O	0.07	0.07	0.05	0.01
N		0.004	0.004	0.01
H		0.10 Max.	0.01	
S	0.012	0.004	0.004	
P	0.010	0.003	0.003	n.d.
Si	0.04	0.01 Max.	0.001	0.0007
Mn	0.05	0.005 Max.	<0.001	0.0003
Mg			<0.0005	0.0002
Ni	0.01	0.05 Max.	0.02	0.0002
Cu	0.07	0.01 Max.	<0.001	0.0001
Na				0.0001
Ag				<0.0001
Cr	0.01	0.005 Max.	<0.003	n.d.
Co	0.007	0.007	0.005	n.d.
Mo	<0.01	0.002	<0.004	n.d.
Al	0.002	0.002	<0.003	n.d.
V	<0.01			

Physical Property Data. Complete and up-to-date information on the physical properties of the elements including melting point, density, coefficients of thermal expansion and values of electrical resistivity are particularly important. For example, a metal which is not an electrical conductor will not be heated in an induction coil at the frequencies normally used, i.e., 450 kc and below. It will also be impossible to initiate an arc in the arc melting process, if the material to be melted is a nonconductor. Use of resistance heating may be indicated, or the use of a susceptor in the induction coil for indirect heating of the non-conducting charge.

Melt Records. Complete melt records must be kept of all work done in the laboratory in the past, including chemical analysis results. In the specialty melting field there is a minimum of duplication of the same analysis. However, there is a limit to the number of elements available to work with so that the same elements are used over and over again, even though they may be in different combinations.

Therefore, it is important that any information that can be obtained about the behavior of each element under a specific set of melting conditions should be accurately recorded for future reference. Information concerning reactivity of an element with certain crucible materials can be of invaluable service in planning future work with this material. Records of chemical analysis on all metals provide a background of information that allows the calculation of charge weights resulting in accurate chemistry without the need for intermediate check analyses during the course of the melting process.

Typical curves of recovery of metals during processing by vacuum induction melting are shown in Figs. 11 and 12. These curves are reliable for most of the melting and deoxidizing techniques in use in the laboratory, and apply to all sizes of heats from a few grams up to 500 lb. It should be emphasized that in the vacuum melting processes, loss of metal is due mainly to vaporization rather than oxidation and formation of slag. It should also be remembered that losses of some metals in an alloy due to vaporization will cause concentration of other lower vapor pressure elements.

Crucible Information. Information on the reactivity of various crucible materials with metals, carbon and hydrogen must be available. Crucible materials which are readily available for use in specialty melting are silica, magnesia, alumina, zirconia, silicon carbide, zircon and graphite. Others which are useful in special cases but are not as readily available are beryllia, thoria and boron nitride.

Most oxide crucible materials will be reduced during a melting cycle, either by the metal being melted or by the deoxidant used. Some of these oxides will be reduced to metals with lower vapor pressure than the charge metals and some to metals with higher vapor pressure. The chances of removing this contaminating metal from the melt are of course much better if its vapor pressure is higher than that of the charge materials. On the other hand, the more resistant the oxide is to reaction

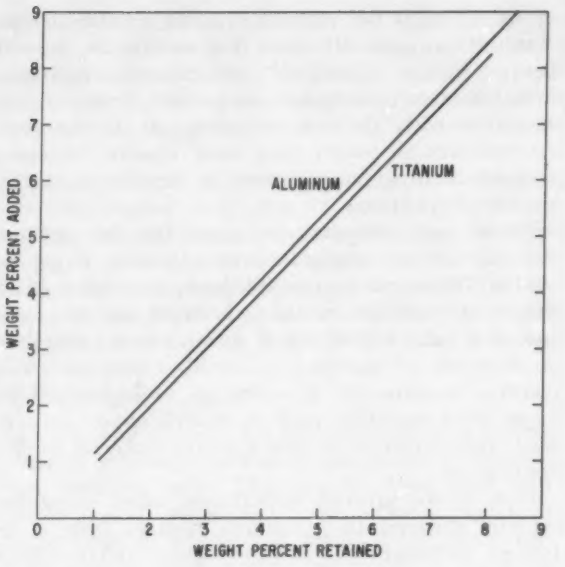


Fig. 11 — Recovery curves for titanium and aluminum in vacuum induction melting.

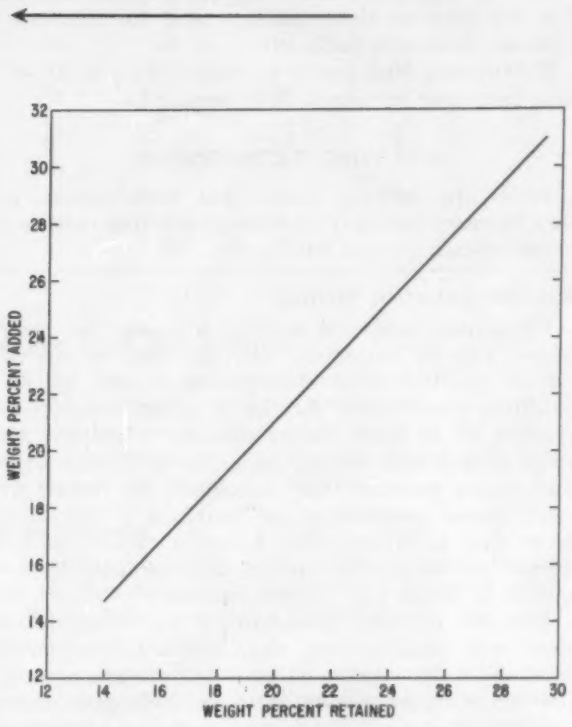


Fig. 12 — Recovery curve for chromium in vacuum induction melting.

during melting, the less chance there is for contamination at all.

In general, stability of the oxides used in crucible manufacture, in contact with metals at high temperatures in order of decreasing reactivity is:[2] ThO_2, BeO, ZrO_2, Al_2O_3 and MgO. The temperatures at which some of these crucible materials show appreciable volatility in vacuum are:[3]

Material	Temperature, F (C)
MgO	3092 (1700)
BeO	3812 (2100)
ZrO_2	4172 (2300)
ThO_2	4172 (2300)
Graphite	4172 (2300)

Of the oxide materials, thoria, zirconia and beryllia appear to be particularly useful in vacuum applications. However, of these, thoria and beryllia have some disadvantages. They are both quite expensive, thoria is radioactive and beryllia has a toxicity problem. In actual practice in the laboratory, magnesia, alumina and zirconia have proved to be satisfactory crucible materials in all but a few exceptional cases. Table 4 is a list of the metals with which the laboratory has become somewhat familiar, and the types of crucibles in which they can be melted with a reasonable chance of success.

TABLE 4 — CRUCIBLES USED FOR MELTING METALS

Graphite	Al_2O_3	MgO	ZrO_2	Zircon	SiO_2	BeO	ThO_2	SiC	Water Cooled Cu	Ta
Al*	Al	Al	Cr	Al	Si*	Cr	Ti	Au*	Cr	Gd*
Sb*	Sb	Sb	Co	Co			Zr	Mg	Cb	Y*
Bi*	Bi	Bi	Au	Fe					Mo	
Cd*	Cd	Cd	Fe	Ni					Ta	
Cu*	Co	Co*	Ni						Ti	
Ga*	Cu	Cu							V	
Au	Ga	Ga							W	
In*	Au	Au							Zr	
Pb*	In	In								
Mg*	Fe	Fe*								
Ag*	Pb	Pb								
Sn*	Ni	Mn*								
Zn*	Pd	Ni*								
	Ag	Ag								
	Sn	Sn								
	Zn	Zn								

*Indicates crucible with which best results have been obtained in this laboratory.

When the questions previously posed have been answered satisfactorily, the melting process best suited to the problem can be chosen. In general, if the metal or alloy falls within these categories it may be vacuum induction melted:

1. Melting point not greater than 3272 F (1800 C).
2. No harmful reaction with either graphite or oxide crucible.

3. The purity required does not exceed 99.99 to 99.999 per cent.

If categories 1 and 2 cannot be met and number 3 is the same as above, then a need for cold crucible arc melting is indicated.

If extremely high purity is desired, then it is possible that zone refining will be required.

MELTING TECHNIQUES

When the melting process has been chosen, it then becomes necessary to determine which variation of the chosen process will apply.

Vacuum Induction Melting

In vacuum induction melting a number of techniques can be employed. Melting may be carried out in vacuum or in atmospheres of inert or deoxidizing gases. Gases may be at a full atmosphere pressure or at some partial pressure. They may be static or dynamic flowing atmospheres. Metals with high vapor pressures may necessarily be melted at some partial pressure of an inert gas to minimize losses due to vaporization. Either a carbon or hydrogen deoxidation technique will normally be required to insure low oxygen content.

The use of solid deoxidants is not desirable as these will usually form slag, which is not easily removed in the vacuum furnace. If hydrogen is used, it is necessary to remove all of the hydrogen before pouring an ingot. If carbon deoxidation is used it is necessary to complete the carbon boil reaction before the pour, as a resumption of the boil in the mold will result in gassy metal.

Even though it is impossible to make high quality material when reactive, pure metals are melted in oxide crucibles, it is possible to add considerable quantities of these metals to form alloys. For example, 80 per cent chromium alloys and 10 per cent titanium or zirconium alloys are possible in oxide crucibles. Ideally, the metals in the initial charge, which normally consist of such metals as iron, cobalt, nickel, chromium, tungsten and molybdenum, should be completely deoxidized before making any late, reactive additions. In this manner complete utilization of the alloying effects of these additions can be realized.

When an inert gas or hydrogen is used, whether it is in induction or arc melting, it is important that the gas be pure and dry. Dew points approaching −100 F are desirable. Purifiers for removing oxygen and dryers for removing water from hydrogen are available. Passing argon over a bed of hot titanium chips will getter most of the oxygen and nitrogen from it, and water may be removed further by trapping. Molecular sieves can also be used to accomplish the same purpose.

Susceptor Use

Not all materials can be melted by direct coupling in an induction furnace. In this case it may be necessary to use a susceptor around the outside of the melting crucible. Heating of the charge is now accomplished by conduction of heat from the susceptor, through the melting crucible to the charge. Graphite is normally used for susceptors, but if there is danger of carbon contamination, molybdenum, tantalum or tungsten can be used. One problem associated with the use of susceptors is the high temperatures at which they must operate in order to reach melting temperatures in the charge in reasonably short times.

These high temperatures aggravate the reaction problem of the susceptor with adjoining oxide ceramics. When using graphite susceptors, lamp black makes an excellent insulator between the susceptor and the coil. When using molybdenum, tantalum or tungsten as susceptor material, either an oxide ceramic material or a series of radiation shields made of a material such as molybdenum may be used. Boron nitride is also a useful material in this application.

It is of the greatest importance, when using any ceramic material in a vacuum furnace, that it be free of moisture and adsorbed gases. All crucibles, molds, pouring basins, etc., should be stored in heated or evacuated areas. It has been experienced that a preliminary conditioning of melting crucibles greatly decreases oxygen pickup from the crucible during the melting process. A wash heat or a furnace fire will accomplish this conditioning.

Casting to shape in a vacuum furnace can be successful only if the mold has been completely dried and has no organic binders to burn out. Of course, casting can be done in organic molds if the furnace chamber is brought to atmospheric pressure before the pour. However, the advantage of pouring into an evacuated mold is lost, with a consequent decrease in yield of good castings. A material made up of various proportions of zircon sand and flour with an aluminum phosphate bond has been used extensively in the laboratory, and has been found to be a universal material for molds, pour basins and pour lips.

A preliminary bake at 392 F (200 C) followed by a firing treatment at 1832 F (1000 C) will prepare this material for use in vacuum. Investment type molds can also be used successfully, including the glass-cast types, if they are properly conditioned.

Cold Crucible Arc Melting

If it is not possible to melt a material in the vacuum induction furnace because of high melting point or reactivity with crucible materials, then it is possible that the material may be successfully made by arc melting in a water cooled copper mold. The greatest degree of purification will be accomplished in the consumable electrode vacuum arc process. Here gases and volatile impurities are removed in vacuum at high temperature. If the vapor pressure of the material is excessively high, partial pressures or full atmospheres of inert gases may be used.

Consumable electrode melting requires that an electrode be formed, either by powder methods (hydrostatic pressing works well) or by fabricating from an ingot or sheet material. If the material to be melted is expensive or not available in a form

easily converted to an electrode, or if only a small quantity is required, then it is possible to melt small quantities (25 to 150 grams) in the button furnace using a tungsten electrode and an inert atmosphere. A static atmosphere of purified argon is used.

This atmosphere is further gettered by melting a zirconium button first and if necessary alternate alloy buttons and zirconium getter buttons. Another method of gettering the atmosphere would be to install a resistance heated strip of titanium or zirconium in the furnace chamber and maintain it at a temperature of about 1382 F (750 C) during melting.

Hot Topping

Hot topping of inert arc melted buttons is accomplished by gradually decreasing the power at the end of the melting cycle. This can be done with consumably melted materials if the adapter to which the electrode is attached is made of tungsten and can be used as a hot topping electrode. In arc melting it is a little more difficult to predict recoveries of various elements in an alloy than in vacuum induction melting because of the higher temperatures involved. This fact makes it even more important that good records be kept on all heats.

Button melting of good heat conductors or high melting point materials is sometimes difficult because in contact with a cold, water cooled copper mold, the heat tends to be withdrawn from the button faster than the arc can replace it. This may result in only one small portion of the button being molten at any one time. This problem is alleviated by rotating the arc around the surface of the button, by stirring the melt with a stirring coil and by melting the button from both top and bottom by turning it over at least once.

Using these precautions it is possible to make sound, homogeneous materials, in quantities sufficient for preliminary evaluation. If results warrant further work, larger ingots can be made.

Kinds of materials which are particularly troublesome in arc melting are alloys in which a high melting reactive material is combined with a low melting, high vapor pressure material. An extreme example of this would be an alloy of titanium and cadmium. The boiling point of cadmium is lower than the melting point of titanium. Tin has a much lower vapor pressure than cadmium, but the problem of a combination of low and high melting point materials is still present in an electrode made up of titanium and tin.

The heat conducted and radiated to the part of the electrode not yet melting in the arc, would heat this portion of the electrode enough to cause the low melting tin to melt and either break the electrode or diffuse out and drop into the melt. Even making a button of this type of alloy in an argon atmosphere, it would be difficult to predict losses of the more volatile element. However, it is surprising the number of different types of alloys that have been made successfully in these arc melting furnaces. Some of the metals that have been melted in one combination or another are listed in Table 5.

TABLE 5 — VARIETY OF METALS MELTED IN SPECIALTY MELTING FACILITY ARC MELTING FURNACES

W	Y	Mn	Ge	Sr
Mo	Gd	Mg	Cu	Mn
Ti	Si	Li	Al	Pd
Ta	Ni	Ba	Ag	Th
Zr	Fe	La	Ca	Pb
V	Co	Hf	B	Nd
Cb	Cr	Ce	Sn	Pr
As	Te	Dy	Pt	Er
Be	C	S	Ga	Au
Tl	Ir	Bi		

Atomic Hydrogen Melting

There are no special techniques involved in the atomic hydrogen melting process except that a gradual decrease in power is necessary at the end of melting in order to hot top the button and keep the shrink up at the top surface.

Zone Refining

In zone refining, the same principles governing the use of high vacuum or atmosphere pressures apply as have been previously discussed for the other melting techniques.

In general narrow molten zones and slow zone travel will effect greater purification than broad zones and rapid zone travel. One method of speeding up this process in the case of horizontal zoning in a crucible is to have a number of molten zones passing through the bar at the same time.

Occasionally requests for single crystals or large crystals of some specific metal or alloy are received. The zone refining apparatus and process are ideal for this purpose. However, a disadvantage is introduced by use of our 450 kc induction source in single crystal growing, since the amount of stirring which is induced in the charge is excessive. This agitation is more conducive to the nucleation and growth of fine grains than large grains.

SUMMARY

Several specialty melting processes and the methods for determining which of these processes will best suit a particular melting job have been discussed. Some of the necessary tools that are used in making this determination are described. Using all of the available data it is possible to determine theoretically how a heat should be processed. However, there is still no substitute for practical experience to back up the theory in specialty melting.

REFERENCES

1. F. D. Richardson and J. H. E. Jeffes, "The Thermodynamics of Substances of Interest in Iron and Steel Making from 0°C to 2400°C," *Iron and Steel Institute*, p. 261 (Nov. 1948).
2. I. E. Campbell, Editor, *High Temperature Technology*, p. 41. Published by John Wiley and Sons, New York and Chapman and Hall, Ltd., London.
3. P. D. Johnson, "Behavior of Refractory Oxides and Metals, Alone and in Combination, in Vacuo at High Temperatures," *J. Am. Ceram. Soc., 33*, (5), 168-171 (1950).

HIGH STRENGTH ALUMINUM ALLOY AIRFRAME CASTINGS

by W. A. Bailey and E. N. Bossing

ABSTRACT

There is a growing trend toward the use of high strength light metal alloy castings as replacement for weldments, machined from bar parts and subassemblies. In the airframe industry this trend has produced considerable savings in cost, time and in facilities necessary for the production of components, as well as savings in weight. This has come about because the cast structure is stronger and more reliable than formerly. High strength and confidence levels can be obtained in almost any properly engineered configuration, and this is of great importance to the airframe industry. These demands must be met or other production methods could replace even the presently cast configurations.

INTRODUCTION

The popularity of high strength, light metal casting alloys, apparently passes through a number of historically recognizable phases, as we can roughly identify a time with a given high strength casting alloy. With magnesium the progression has been from AZ63 to AZ91 to the edge of the ZK51-ZK61-QE22 era. With aluminum it has been from the brittle epoch of 195 through a brief and mostly painful 220 period and then, rapidly into the aluminum-magnesium silicide alloys. Today could be called, according to these chronological systematics, mid 356.

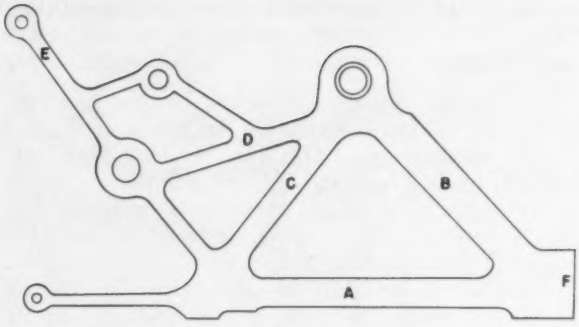
To all the various modifications of the parent 356 aluminum alloy—A356, 356 CMB, X357, 356Be, Tens-50—it is thought that much of the current increased emphasis on cast structure in airframes is owed.

Within the authors' company, as elsewhere, there is a growing trend toward the use of high strength light metal alloy castings as replacements for weldments, machined from bar parts and subassemblies. To those in the airframe industry, the consequence of this trend seems increasingly attractive, for such use has already produced considerable savings in cost, in time, in the facilities necessary for the production of components and, happily, in weight. The origin of this trend must be in a generally held opinion that cast structure is stronger and more reliable today than it was formerly. This opinion appears to be fairly well founded in fact.

LANDING GEAR ASSEMBLY

As an example, there was a cast 356 aluminum alloy bracket in a landing gear assembly that failed.

W. A. BAILEY and E. N. BOSSING are with Douglas Aircraft Co., Santa Monica Div., Santa Monica, Calif.



356-T6 ALUMINUM ALLOY

Location	Purchased Per QQ-A-601 FTU	FTY	E,%	Purchased Per DMS 1561-A FTU	FTY	E,%
A	20.9	16.5	3.0	48.9	39.5	8.0
B	25.5	18.7	2.0	49.5	40.1	8.0
C	24.3	16.0	4.0	49.5	38.5	10.5
D	26.6	20.6	2.0	49.4	38.9	10.0
E	30.9	20.6	5.0	50.4	38.9	16.0
F	30.6	20.8	5.0	50.9	37.9	17.0

Fig. 1 — Bracket in landing gear assembly. Letters indicate test coupon locations.

The casting was purchased under the Federal Specification QQ-A-596, and is diagramed in Fig. 1. The mechanical properties obtained from a similar casting of the same heat, which incidentally was filled with gas porosity, are listed in the left hand column. The letters on the diagram show the location of the test coupons. This part according to the Federal Specification is a legal part despite the low mechanical properties and despite the fact that the casting failed in use. It required only 1000 lb to break a similar test casting statically loaded to failure.

Legal part or no legal part, the authors' company grew discouraged with both the producing foundry and some aspects of the Federal Specification. It was tried again using a new foundry and a new specification (company Material Specification 1561). This requires both a high purity A356 aluminum alloy chemical composition and guaranteed minimum mechanical properties in a specified highly stressed area of the casting. What was learned about its mechanical properties, is listed in the right hand column of Fig. 1. A similar part failed on static test at about a 3000 lb load, approximately three times the loading of the first casting. There has never been a service failure of these castings.

This example of the basic improvement in mechan-

ical properties of coupons cut from castings and in the static strength of cast structure is typical of many high strength castings now in use at the authors' company. It is due primarily, not to a new and startling alloy but to the better application of well known foundry principles, principles which have been recognized for years. Unfortunately, most of the attention which has been paid to them is paid in lip service, and lip service does not improve the quality of a given casting anymore than does shining x-rays through it.

Of course, some of this improvement has come through alloy modification, as in the case of 356 aluminum alloy, where apparently a decrease in iron content is reflected by a corresponding increase in resultant elongation. This increased elongation, as you know, can be taken advantage of by increasing artificial aging times and temperatures to higher yield strengths while maintaining a given ductility. But uncomplicated by chill, by tailored heat treat, how much of this is due to actual reduction of iron content? Rather less than initially thought.

TENSILE DATA

The origin of the data, presented in the table, are from a number of tensile coupons cut from several castings poured in each of three aluminum alloys. The castings were poured into green sand and were identically gated. The differences here should be principally due to alloy. As can be seen, the major variation in chemistry between the 356 and A356 aluminum alloys is one of iron content, the iron in the standard 356 being approximately double that contained in the high purity material.

As can be seen the A356-T6 aluminum alloy material has an advantage over standard 356 in elongation regardless of section thickness—some of this elongation has already been taken advantage of by an apparent increase in artificial aging to a higher yield. The results from Tens-50-T6 aluminum alloy, also shown in the table, are to demonstrate what can be done to mechanical properties by a simple composition change. The beryllium in part negates the embrittling effect of iron, but only in part as witnessed by lower elongation.

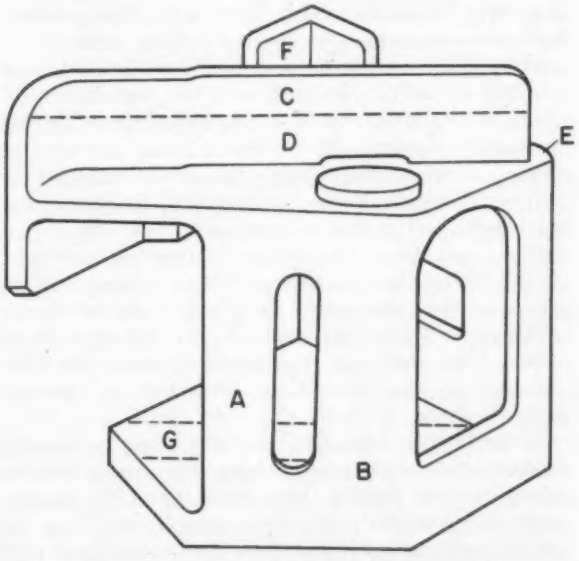
With these results, the extent of the simple effect of composition variation in 356 type aluminum alloys has roughly been demonstrated. The improvement in mechanical properties is significant, but nothing approaching the advance in tensile strengths shown in Fig. 1, especially in elongation.

COMPARISON OF MEAN MECHANICAL PROPERTIES FOR SIMILAR SECTIONS OF THREE ALUMINUM CASTING ALLOYS

Section Thickness, in.	Test	Aluminum Alloy 356	A-356	TENS-50
1¼	FTU	28,140	32,995	38,620
	FTY	20,525	25,715	32,850
	E,%	4.0	4.4	2.5
¾	FTU	28,800	34,115	41,330
	FTY	21,370	26,850	35,650
	E,%	4.0	5.1	4.0
⅜	FTU	30,640	35,345	42,875
	FTY	22,110	26,910	36,880
	E,%	4.0	5.6	3.0
¾	Bending Modulus	56,160	69,325	74,475
⅜	Bending Modulus	61,935	73,785	80,570

Chemistry

Element	Aluminum Alloy, Composition, % 356	A-356	TENS-50
Copper	0.015	0.015	0.033
Magnesium	0.30	0.32	0.42
Silicon	7.5	7.4	8.2
Iron	0.34	0.18	0.36
Titanium	0.11	0.11	0.13
Beryllium	—	—	+



HINGE CASTING — A-356 ALUMINUM ALLOY

Location	Foundry A FTU	FTY	E,%	Foundry B FTU	FTY	E,%
A	32.5	27.6	1.9	46.0	32.0	13.7
B	32.1	28.1	1.6	46.2	31.7	14.8
C	35.2	29.5	3.6	46.2	31.2	15.3
D	35.2	29.9	2.9	45.9	31.7	14.8
E	34.4	29.2	2.3	45.8	32.1	14.8
F	31.8	27.7	2.1	45.4	33.3	14.0
G	33.3	29.0	2.4	45.8	32.1	13.3

Fig. 2 — Hinge casting produced in sand by two different foundries.

HINGE CASTINGS

So there is still left much of the question "why?" The answer perhaps can be found in the data presented in Figure 2. These are data from a number of DC-8 hinge castings found in A356 aluminum alloy. The castings were produced in sand by two different foundries. Both compositions fall within the specification for high purity A356 aluminum alloy—silicon is between 6.5 and 7.5 per cent, iron lies below 0.20 per cent and the magnesium between 0.20 and 0.40 per cent. Both foundries have produced castings in the solution heat treated and aged condition.

Radiographically the castings are comparable. And yet foundry *B* has produced mean mechanical properties of 46.0 ksi ultimate strength, 32.0 ksi yield strength and 14.5 per cent elongation as opposed to 33.0 ksi ultimate, 29.0 yield and perhaps 2.5 per cent

elongation from foundry *A*. Foundry *A* has produced a fairly good average casting, Foundry *B* has produced a superior casting. How did foundry *B* manage this?

First, by chilling heavily. Chill, besides disguising the presence of gas does have some function other than moving around radiographically visible defects. This, in conjunction with optimum gating and a sound knowledge of progressive solidification, is to a large extent responsible for the superior mechanical properties.

Second, by keeping the magnesium content of this alloy near the upper reaches of the specification—0.35 per cent as opposed to 0.20 per cent in the poorer castings.

Third, by adequate heat treatment fashioned to the requirements of the part. Solution heat treat temperatures of 980-1000 F are used standardly on 356 aluminum alloy. The high purity material should in theory contain a smaller quantity of low melting point eutectic compounds. This reduced amount of eutectic would permit the use of a higher temperature in solution heat treatment, resulting ultimately in higher and more reliable mechanical properties. In all probability foundry *B* used a slightly higher solution temperature coupled with an extremely rapid water quench.

This rapid quenching is extremely important. And this fact unfortunately leaves many foundries literally at the mercy of their heat treaters. These heat treaters, it would seem, are often aware enough of the need for rapid quenching to fix the separately cast test bars representing a heat treat load to the periphery of that load, but are not aware enough to similarly quench the castings so represented.

Using a low iron, high magnesium A356 aluminum alloy ingot, with little scrap in the melt, with adequate degassing, with heavy chilling and good gating, coupled with adequate solution heat treatment, a rapid quench and judicious aging, a part is produced with superior mechanical properties, properties which a few years ago would have been considered impossible or at least improbable for production. The high mechanical properties, shown in Fig. 2, were from production castings. The things combining to produce a superior part are not new foundry techniques; they are old foundry techniques at last being used.

CASTING TECHNOLOGY IMPROVEMENTS

Thus, much of the so-called improvements in casting technology and in alloys and their resultant reflection in part strength have originated not from revolutionary foundry techniques, but from the application of well known principles to existing alloys. The greater part confidence has come not from magic, but from more extensive use of radiographic techniques and from sampling directly the mechanical properties of castings randomly selected from a submitted casting lot — no longer depending upon a separately cast test bar reputedly representative of a given production order. Apparently, awareness is coming that castings are flown, not separately cast test bars.

Recently, of course, there have been many alloy developments in both aluminum and magnesium. These alloy developments most foundrymen grasp eagerly in their constant search for a panacea, a cure-all, a crutch which will enable them to pour sounder, stronger parts with no more effort and no more cost than they are accustomed to expending. To date there is no such alloy now anymore than there was back in 1500 when a gentleman named Theophrastus Paracelus also searched for it unsuccessfully. Foundries in 1961 will produce stronger more reliable parts when they actually apply those principles which they profess to understand.

It would seem that a thesis has been developed — that much of the apparent improvement in casting technology, and its resultant reflection in part strength, has come about almost exclusively from the strength and confidence demands of foundry customers, ably assisted by those foundrymen owning curiosity and technical competence and who are willing to use them. For foundries will, in general, produce no better parts than the poorest part that will be accepted. This is economics, but it is neither science or progress.

CUSTOMER SATISFACTION

It seems more foundry customers should turn into benevolent despots and continue to force the bulk of founders to advance. To demand high mechanical properties for castings themselves, not in little bars of metal ideally gated. To sample statistically lots of castings to insure themselves of part confidence, not to grossly over-design, and in over-designing, knowingly compensate for the expected foundry error.

That this road has been traveled is evidenced tangibly by MIL specification 21180, by the A revision of QQ-M-56 and by a host of company specifications. However, still a considerable amount of prejudice exists concerning the use of castings in airframes. Much of this prejudice is based on the historical unreliability of castings. It has resulted in the present use of casting factors that produce part weights which are excessive. These casting factors may not be ultimately realistic in light of recent advances in alloys and especially in the application of foundry techniques, but they must serve until the old-new processes have been evaluated and demonstrated reliable.

A handful of foundries are at present producing massive aluminum alloy castings for certain missile configurations, castings with extremely high guaranteed mechanical properties, complicated castings which demonstrate the authors' contention that high strength and confidence levels can be obtained in almost any properly engineered configuration. That this is often difficult is not doubted, but the aim is of paramount importance to the airframe industry. Certainly such strength and confidence level requirements are steadily increasing.

They may well ultimately become mandatory for almost all cast airframe structure. In order for the foundry industry to survive, such demands must somehow be met, or other production methods will replace even those configurations presently cast. An industry that suffers from stasis cannot long survive.

HIGH STRENGTH YELLOW BRASS CASTINGS WELD REPAIR

by Donald K. Fox

ABSTRACT

An investigation was conducted on the repair welding of high strength yellow brass castings. Test castings oxyacetylene gas and inert-gas-shielded-arc welded with several types of fillers were evaluated. Tensile and bend tests on samples removed from these castings showed that satisfactory high strength, high ductility welds could be obtained by inert-gas-shielded-arc welding with base metal composition filler and high manganese aluminum bronze alloy filler. Several production castings welded in this manner supported the experimental results. Additional information is presented on microhardness tests and metallographic interpretation of the weld deposits.

INTRODUCTION

The cast high strength yellow brasses, known also as the manganese bronzes, are employed extensively throughout industry for a wide range of applications. The popularity of this class of materials with designers and foundrymen alike is due, to a great extent, to the high mechanical strengths developed in the as-cast condition and the lower cost per pound of finished casting compared to other nonferrous casting alloys providing similar mechanical properties. In our own corporation, the cast manganese bronzes are employed for grid supports in oil circuit breakers, bushings in turbine generators and resistance rings in large motors. Other industrial applications include marine propellers, heavy duty gears, valve and rolling mill bearings.

For the most part, the casting of these high strength alloys presents no difficulty, providing good melting practices are followed and careful consideration is given to gating and risering systems. Occasional difficulties, however, with misruns, shrinkage and dross inclusions do occur in complex castings where adequate feeding, directional solidification and nonturbulent metal flow is more difficult to achieve than with the simpler shapes. In these instances, it becomes advantageous from both the viewpoints of cost as well as of production scheduling to be able to salvage these defective castings by weld repairing.

The amount of commercial as well as technical literature devoted to the welding of copper-zinc alloys, and particularly the high strength yellow brass casting alloys, is not extensive. Although gas welding is normally reported to be the most common technique used for the brasses, and some detailed information is often given to provide a procedure for welding, little has been devoted to the evaluation of welded castings and test bars removed from these castings. In order to obtain such information, which the author's company believes paramount to the acceptance of repair welding as a salvage procedure for high strength yellow brasses, an investigation was initiated on experimental castings oxyacetylene gas welded and inert-gas-shielded-arc welded utilizing several different filler metals. The results of this investigation are described herein.

TEST CASTINGS PREPARATION

For this investigation, it was decided to conduct mechanical tests and metallurgical examinations on welded high strength yellow brass castings cast to the shape of the test plate, described in the A.S.T.M. Specification B225. A sketch of this plate and location of test specimens is shown in Fig. 1.

In collaboration with the author's company's brass foundry, a rigging which was anticipated to provide sound, dross-free castings was designed and employed in a matchplate pattern for producing the high strength yellow brass test castings in green sand molds. This rigging design utilized a short ½-in. diameter downsprue, 1½-in. diameter by one in. deep sprue well, 1½-in. wide by one in. deep tapered runner and ⅛-in. thick flash gate to provide a gating ratio of 1 : 6½ : 4.

To assure adequate feeding during solidification, four 1½-in. diameter by 4 in. high, plaster insulated risers were provided on the cope side of the castings. A control casting, not to be welded, was cast solid by removing the section of the pattern which provided the 60 degree groove shown in Fig. 2. Radiographic examination of sample plates showed the rigging design to be satisfactory in providing castings suitable for the welding experiments.

WELDING TEST CASTINGS

The nominal chemical compositions of the test castings and filler metals used in the experiment are shown in Table 1. The high strength yellow brass castings were made of an alloy which is similar in

D. K. FOX is Met. Engr., Westinghouse Electric Corp., Materials Labs., East Pittsburgh, Pa.

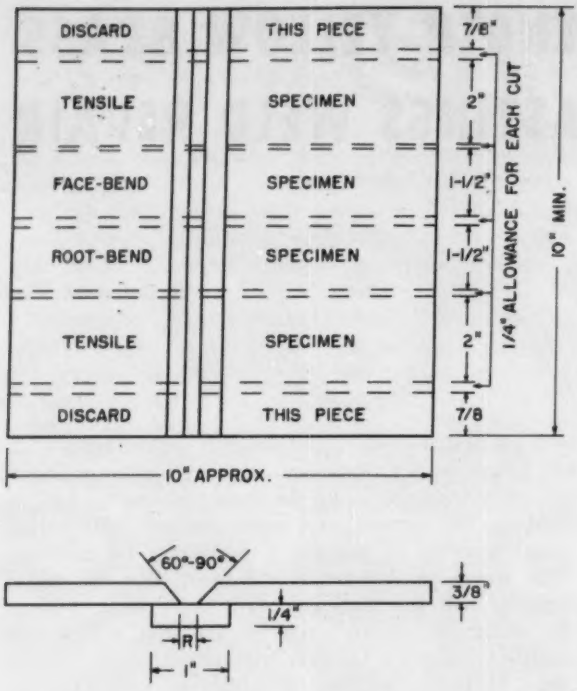


Fig. 1 — Welding mechanical test assembly.

composition and mechanical characteristics to the A.S.T.M. 8B manganese bronze sand casting alloy. In the tables, as well as the following discussion, castings and filler metals made of this alloy will be referred to as "manganese bronze 8B alloy."

Three of the test castings were oxyacetylene gas welded employing in two instances filler metals similar in composition to the base metal, and in the other a low fuming manganese bronze filler corresponding to the A.W.S.-A.S.T.M. classification RCuZn-C. The castings were wire brushed in the groove area, preheated to a temperature of about 750 F (400 C) and welded using a slightly oxidizing flame. Fluxing was accomplished by frequently dipping the welding rod into a pool of molten borax. Four passes of 3 min duration each were needed to complete each weld. After welding and cooling to a somewhat lower temperature, the castings were stress relieved at 1022 F (550 C) for one hr and furnace cooled.

Six additional castings were inert-gas-shielded-arc welded with six different filler metals. The fillers were:

1) Low fuming manganese bronze (A.W.S.-A.S.T.M. RCuZn-C).
2) Aluminum bronze (A.W.S.-A.S.T.M. RCuAl-A2).
3) Medium strength aluminum bronze alloy (A.S.T.M. 9A aluminum bronze alloy).
4) High strength aluminum bronze alloy (A.S.T.M. 9D aluminum bronze alloy).
5) High strength manganese bronze alloy (A.S.T.M. 8B manganese bronze alloy).
6) High manganese aluminum bronze alloy.

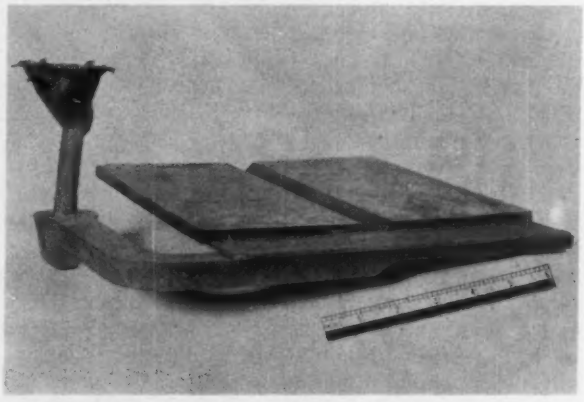


Fig. 2 — Cast test plate with attached gating system. Gating ratio 1 : 6.5 : 4.

TABLE 1 — CHEMICAL COMPOSITIONS OF TEST CASTINGS AND FILLER METALS

Welding Process	Control Casting	Oxyacetylene			Shielded Arc					
Filler Metal		Manganese Bronze (8B)	Low Fuming Manganese Bronze	Manganese Bronze (8B)	Low Fuming Manganese Bronze	Aluminum Bronze	Aluminum Bronze (9A)	Aluminum Bronze (9D)	Manganese Bronze (8B)	High Manganese Aluminum Bronze
A.W.S.-A.S.T.M. Classification	—	—	RCuZn-C	—	RCuZn-C	RCuAl-A2	—	—	—	—
Nominal Comp. Test Castings										
Copper, %	60	60	61	63	58	58	61	63	58	58
Iron, %	1.0	1.0	1.0	1.0	1.5	1.5	1.0	1.0	1.5	1.5
Manganese, %	3.0	3.0	3.0	2.0	3.5	3.5	3.0	2.0	3.5	3.5
Aluminum, %	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	5.0	5.0
Zinc, %	33	33	33	32	34	34	32	31	32	33
Nominal Comp. Filler Metal										
Copper, %	—	60	56	60	56	88	88.7	78	60	75
Iron, %	—	1.0	0.6	1.0	0.6	1.5	2.3	3.7	1.0	3
Manganese, %	—	3.0	0.25	3.0	0.25	—	—	—	3.0	12
Aluminum, %	—	3.0	—	3.0	—	10	9.0	10.8	3.0	8
Zinc, %	—	33	41	33	41	—	—	—	33	—
Tin, %	—	—	0.75	—	0.75	—	—	—	—	—
Nickel, %	—	—	—	—	—	—	—	4.0	—	2

TABLE 2 — MECHANICAL TEST RESULTS ON WELDED HIGH-STRENGTH YELLOW BRASS CASTINGS

Welding Process	Control Casting	Oxyacetylene			Shielded Arc					
Filler Metal		Manganese Bronze (8B)	Low Fuming Manganese Bronze	Manganese Bronze (8B)	Low Fuming Manganese Bronze	Aluminum Bronze	Aluminum Bronze (9A)	Aluminum Bronze (9D)	Manganese Bronze (8B)	High Manganese Aluminum Bronze
A.W.S.-A.S.T.M. Classification	—	—	RCuZn-C	—	RCuZn-C	RCuAl-A2	—	—	—	—
Flux	—	Borax	Borax	Borax	—	—	—	—	—	—
Stress Relief	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No
Tensile Strength, psi	93,300	26,900	34,300	42,400	47,400	68,500	74,000	76,200	70,800	90,000
Yield Strength, psi	50,000	24,100	18,200	34,600	23,000	52,000	30,000	33,000	27,000	47,000
Elong., %	18.7	4.5	10.1	4.3	10.8	3.7	12.0	8.5	16.7	6.7
Brinell hardness, 3000 Kg. Load	185	—	—	—	—	—	—	—	—	—
Fracture	—	Weld	Weld	Weld	Weld	Weld	Weld	Weld	Weld	Outside Weld
Root Bend, degrees	180	17.5	180	33	139	9.5	43	25	48	72
Face Bend, degrees	180	16	180	21	111	23	87	30	88	81
Fracture	—	Weld	—	Weld	Weld	Weld	Weld	Weld	Weld	Outside Weld

A conventional tungsten nonconsumable electrode, helium atmosphere and 150 ampere d.c. current (straight polarity) were employed during welding along with approximately ¼-in. thick uncoated filler rods. The castings were preheated to a temperature of about 750 F (400 C) and wire brushed between each pass to remove any deposited zinc oxide resulting from volatilization of zinc from the base metal. Four passes of 3 min duration each were required to complete each weld. The castings welded with the low fuming manganese bronze and aluminum bronze RCuAl-A2 filler metals were stress relieved at 1022 F (550 C) whereas the remaining 4 castings were tested as-cast.

WELDED TEST CASTINGS EVALUATION

Transverse tensile and guided bend test specimens of the dimensions, shown in Fig. 3, were removed from both the welded and nonwelded test castings. The results of these tests are shown in Table 2. Compared to the properties of the nonwelded high strength yellow brass control casting, the mechanical characteristics of castings oxyacetylene gas welded with manganese bronze 8B alloy and low fuming manganese bronze alloy fillers were inferior. In the case of the manganese bronze 8B filler, the appearance of the test bars before and after testing indicated that excessive porosity caused by zinc volatilization from the casting and filler contributed to the poor properties. All test bar fractures occurred through the welds.

Inert-gas-shielded-arc welding with the several different fillers resulted in test bar values that in some instances approached those of the high strength yellow brass control casting. Of particular note are the results on the casting welded with the high manganese aluminum bronze alloy. Fracture occurred outside the weld at a load near the typical ultimate strength of the high strength yellow brass parent metal. The rather low 6.7 per cent elongation exhibited by the parent metal is attributed to the somewhat higher than desired aluminum content of the test casting (Table 1).

High ductility (16.7 per cent) was obtained from the casting welded with parent metal composition (manganese bronze 8B alloy) but tensile properties were lower than expected. This circumstance is believed to have been caused by a loss of zinc during welding. The other welded castings, except that welded with aluminum bronze RCuAl-A2 filler, showed good combinations of strength and ductility, but not of the level desired for the high strength yellow brasses.

Originally it was intended to stress relieve all castings after welding, however, the ductility of the casting welded with the RCuAl-A2 filler was so unusually low it was concluded that the stress relief treatment had resulted in an undesirable eutectoid transformation in the weld desposit causing the loss in ductility. For this reason, the remaining castings welded with aluminum bronze fillers were not stress relieved following welding.

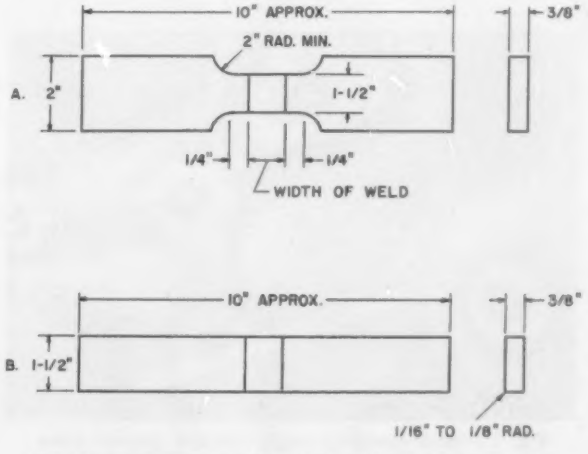


Fig. 3 — Transverse tension (A) and guided bend (B) test specimens.

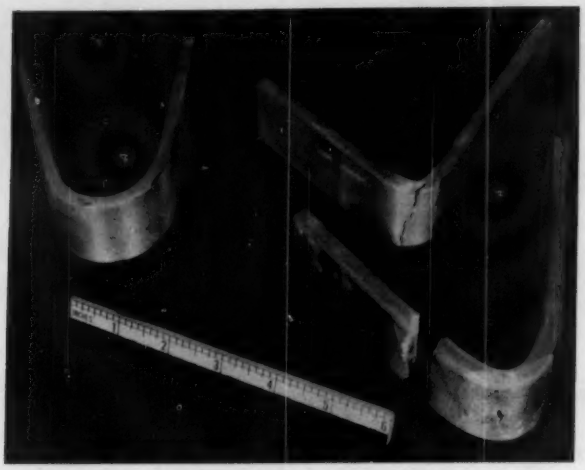


Fig. 4 — Bend tests on high strength yellow brass specimens as welded with low fuming manganese bronze filler rod (A.W.S.-A.S.T.M. RCuZn-C).

Bend Test Specimens

Guided bend test specimens were placed in a die-plunger jig, and bent until the specimens conformed to a U-shape or cracks appeared on the convex surfaces. One face-bend and one root-bend test was performed on each of the test castings. The face-bend samples were placed in the die member with the faces of the welds toward the die gap, whereas the root-bend samples were placed with the roots of the welds toward the gap. As shown in Table 2, aside from the casting oxyacetylene gas welded with low fuming manganese bronze, none of the welded test specimens were able to sustain 180 degree bends as had the nonwelded control casting.

A considerable amount of ductility in bending was revealed by most of the inert-gas-shielded-arc welded specimens, especially those welded with low fuming manganese bronze and high manganese aluminum bronze. In the latter instance, cracks initiated in the parent metal rather than in the weld deposit. Figures 4 and 5 show several of the bend test specimens compared to a sample from the control casting.

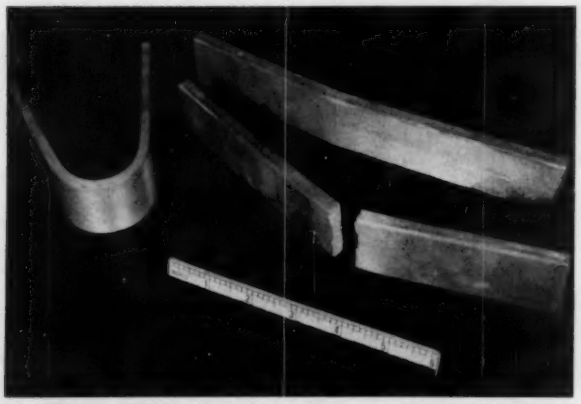


Fig. 5 — Bend tests on high strength yellow brass specimens arc welded with aluminum bronze filler rod (A.W.S.-A.S.T.M. RCuA1-A2).

To determine if there were variations in hardness in the weld deposits or a brittle fusion zone at the weld-parent metal interfaces, microhardness tests were conducted on sections of the inert-gas-shielded-arc welded castings normal to the direction of welding. Before testing, the samples were etched with a solution of potassium dichromate to reveal the structure of both the weld and parent metal. Figure 6 shows one of the samples and location of Vickers microhardness impressions taken every 0.1 in. across and down the weld.

The numbers below the photograph correspond to the transverse hardness values on the several welded castings. There was no evidence of any brittleness in the welds or parent metal adjacent the welds. The somewhat lower hardness in the manganese bronze 8B filler deposit supports the previously stated opinion that some zinc was lost during welding. Spectrochemical analysis of the deposit also showed zinc to be below that in the original filler rod. The highest weld hardnesses were obtained with the aluminum bronze 9D alloy and the high manganese aluminum bronze alloy, whereas the lowest hardnesses were realized with the low fuming manganese bronze filler.

METALLOGRAPHIC EXAMINATION

Figures 7 through 12 show portions of the weld-base metal interfaces in the several inert-gas-shielded-arc welded castings at 100 ×. The base metal is shown at the top portion of each photograph, all consists of an all beta solid solution matrix through which is dispersed a star-like iron-rich compound. Variations in the shading of grains is the result of preferential attack by the etching solution. Figure 7 reveals the duplex alpha plus beta structure of the low fuming manganese bronze filler. Although somewhat difficult to discern, the alpha constituent appears plate-like, whereas the beta constituent is a continuous matrix. The weld is sound and well fused to the base metal. Alloying appears to have been limited to about one grain diameter.

Figure 8 indicates that stress relieving welded high strength yellow brasses at a temperature of 1022 F (550 C) can cause an appreciable amount of brittle eutectoid to form in aluminum bronze weld deposits. This circumstance, as stated previously, is believed to have caused the low ductility in the tensile and bend specimens of the sample shown. The white, needle-shaped constituent in the weld is the copper-aluminum solid solution alpha phase, whereas the dark constituent is finely divided eutectoid (alpha plus gamma phase).

Figure 9 is interesting in that a dark continuous band is readily observed between the base metal and weld deposit. The nature of this fusion zone is similar to the eutectoid viewed in the previous photograph. The remainder of the weld consists essentially of a copper-aluminum alpha matrix with small patches of eutectoid. A narrow portion of the heat affected zone adjacent the eutectoid band is duplex alpha plus beta which fuses within about two grain diameters into the all beta matrix. Figure 10 shows a portion of the weld-base metal interface of

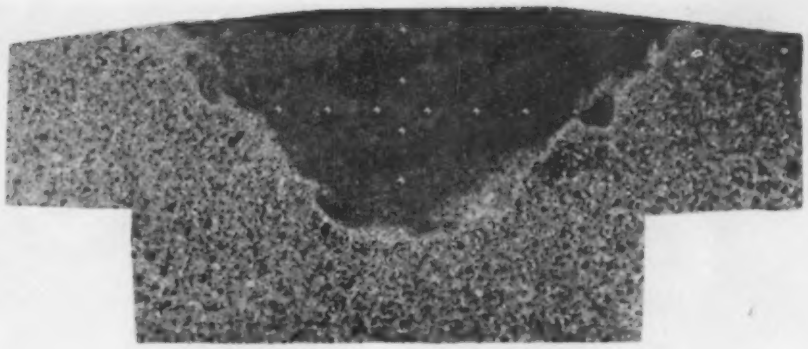


Fig. 6 — Etched cross-section of welded specimen with hardness indentations (see table).

HARDNESS MEASUREMENTS ON WELD DEPOSIT AND PARENT METAL

Bhn 3000 Kg. converted from Dph (see Fig. 6).

Low Fuming Manganese Bronze (RCuZn-C)	Aluminum Bronze (RCuAl-A2)	Aluminum Bronze (9A)
175	175	182
177	178	178
165	179	175
83	137	138
84	138	137
69 Weld	138 Weld	131 Weld
79 Metal	138 Metal	135 Metal
74	135	135
79	135	137
84	135	140
172	175	167
173	165	172
175	165	175
Aluminum Bronze (9D)	**Manganese Bronze (8B)**	**High Manganese Aluminum Bronze**
175	173	173
175	173	165
178	169	162
194	148	173
199	148	175
195 Weld	148 Weld	173 Weld
193 Metal	151 Metal	175 Metal
194	145	184
192	153	175
190	155	175
175	178	167
184	173	163
184	173	167

the casting welded with aluminum bronze 9D alloy. In this case, the weld consists primarily of small copper-aluminum beta grains surrounded by an alpha constituent. At the point of fusion, the phases present in the heat affected zone are equiaxed beta and alpha plus beta.

The manganesé bronze weld deposit, shown in Fig. 11, consists of a mixture of small copper-zinc alpha plus beta phases. The loss of zinc during welding and illustrated by the low hardness values and low tensile and yield strengths of the test bars undoubtedly accounts for the lack of a complete beta structure in the weld. A rather sharp fusion line defines the weld-base metal interface. Figure 12 presents a photomicrograph of the weld consisting of the high manganese aluminum bronze alloy. Fusion is quite extensive, and several different structures can be observed in the heat affected zone. The high manganese aluminum bronze consists primarily of copper-aluminum alpha phase with some dispersed beta.

WELDING PRODUCTION CASTINGS

As a further step in this experimental program, several castings from a production lot of high strength yellow brass were purposely slotted and routed, as shown in Fig. 13. Utilizing the same techniques employed on the plate-shaped castings, these production castings were inert-gas-shielded-arc welded with either base metal composition filler rod (manganese bronze 8B alloy) or high manganese aluminum bronze alloy filler. Figure 14 shows two of these castings after welding. The casting to the left in the photograph has been welded with base metal composition filler.

Some zinc splatter can be observed as a white coating on the weld and part of the casting. The casting to the right has been welded with high man-

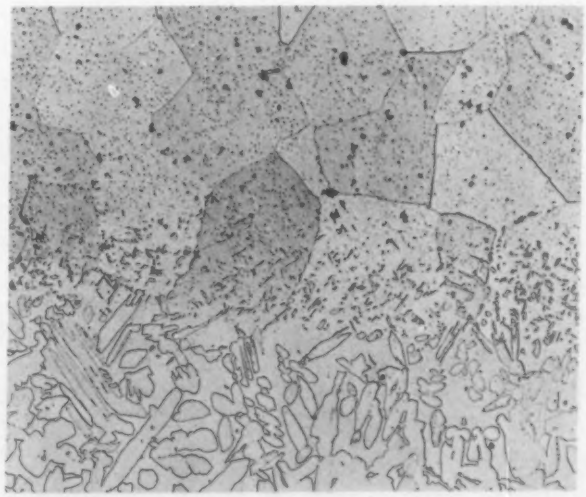


Fig. 7 — Arc welded high strength yellow brass. *Top* — base metal; *bottom* — low fuming manganese bronze filler (RCuZn-C). $K_2Cr_2O_7$ etch. 100 ×.

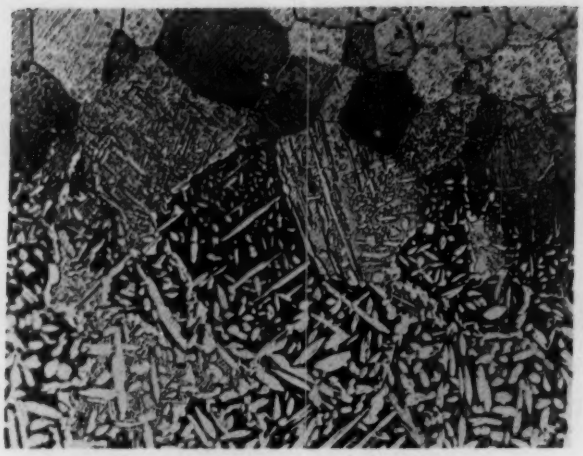


Fig. 8 — Arc welded high strength yellow brass. *Top* — base metal; *bottom* — aluminum bronze (RCuA1-A2). $K_2Cr_2O_7$ etch. 100 ×.

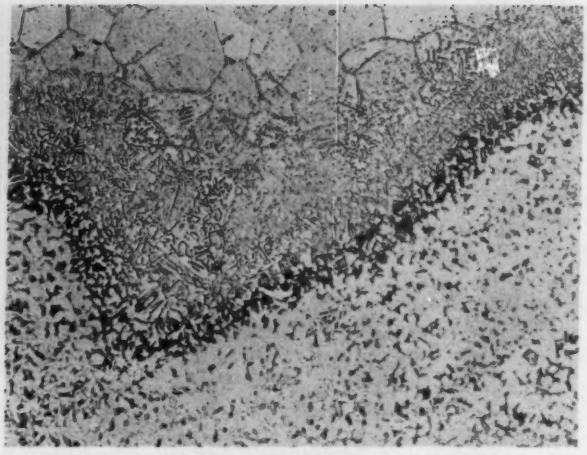


Fig. 9 — Arc welded high strength yellow brass. *Top* — base metal; *bottom* — aluminum (9A). $K_2Cr_2O_7$ etch. 100 ×.

ganese aluminum bronze filler. A smaller amount of zinc was volatilized and the bead appeared cleaner and more uniform than its counterpart in the casting to the left.

The welded high strength yellow brass castings are shown again in Fig. 15 (position has been switched from Fig. 14) after removing the weld flash from the tongue portions of the castings. The color match was good in the casting welded with the base metal composition filler. The color match in the casting welded with high manganese aluminum bronze was not quite as good because of the silvery appearance of the weld deposit. Fusion was good in both samples, and both the welds and base metals showed complete absence of surface porosity and other discontinuities.

To investigate the effect of stress relief treatment on the welded castings, several of them were heated to a temperature of 102 F (550 C) for one hr and furnace cooled. Brinell hardness values on these castings before and after stress relieving showed little variation as a result of the heat treatment. The high manganese aluminum bronze is reportedly not prone to a brittle eutectoid transformation at temperatures of about 1022 F (550 C).

This circumstance makes it possible to stress relieve high strength yellow brass castings welded with the high manganese aluminum bronze at the conventional stress relieving temperatures without concern for developing undesirable structures in the weld. The Brinell hardness values on the deposited manganese bronze 8B composition were on the order of about 180 (3000 kg. load). This indicates that properties close to that of the control test casting previously discussed could be obtained from the weld.

CONCLUSION

Based on the results obtained in this investigation, it is concluded:

1. High strength yellow brass castings can be successfully repair welded using inert-gas-shielded-arc welding techniques.

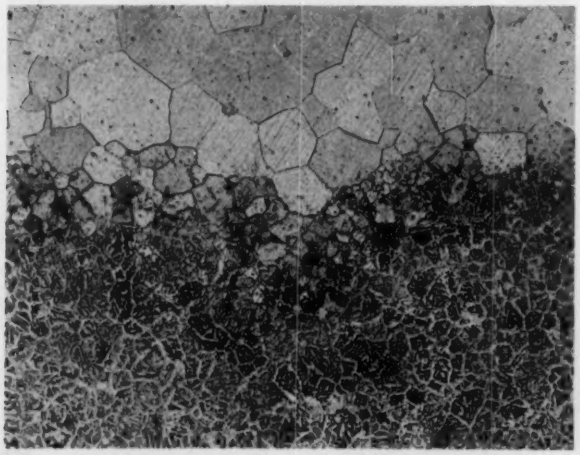


Fig. 10 — Arc welded high strength yellow brass. *Top* — base metal; *bottom* — aluminum bronze (9D). $K_2Cr_2O_7$ etch. 100 ×.

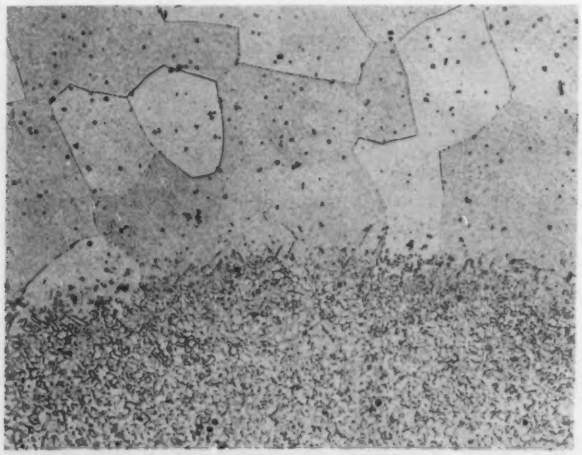


Fig. 11 — Arc welded high strength yellow brass. *Top* — base metal; *bottom* — manganese bronze (8B). $K_2Cr_2O_7$ etch. 100 ×.

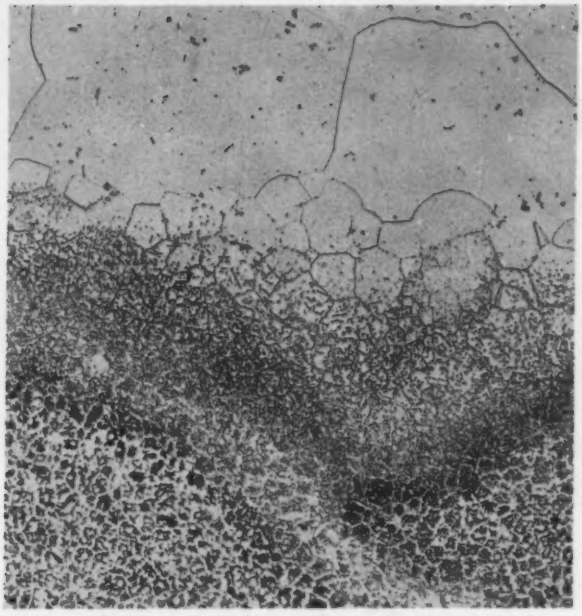


Fig. 12 — Arc welded high strength yellow brass. *Top* — base metal; *bottom* — high manganese aluminum bronze. $K_2Cr_2O_7$ etch. 100 ×.

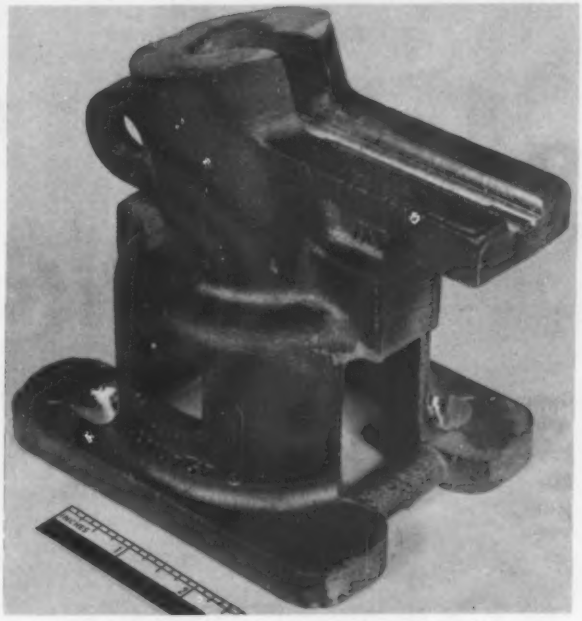


Fig. 13 — High strength yellow brass casting with machined slot and routed corners.

2. Satisfactory high strength, high ductility welds can be obtained with both high manganese aluminum bronze filler metal as well as manganese bronze 8B alloy. A greater amount of variation in the properties of welds made with the latter material would be expected as a result of the zinc volatility problem.
3. Color match is better in high-strength yellow brasses welded with the manganese bronze 8B alloy than those welded with high manganese aluminum bronze. Where color match is not important, however, either material can be used.
4. High strength yellow brasses repair welded with either of the two filler metals can and should be stress relieved at a temperature of about 1022 F (550 C) to minimize residual stresses caused by welding.

REFERENCES

1. E. G. West, *The Welding of Non-Ferrous Metals*, John Wiley & Sons Inc., New York.
2. *Welding Handbook*, Third Edition, American Welding Society, New York (1956).
3. *Copper and Copper-Alloy Arc-Welding Electrodes*, A.S.T.M. Designation B225-57T.
4. Copper and Copper-Alloy Welding Rods, A.S.T.M. Designation B259-57T.
5. High-Strength Yellow Brass (Manganese Bronze) and Leaded High-Strength Yellow Brass (Leaded Manganese Bronze) Sand Castings, A.S.T.M. Designation B147-52.
6. Aluminum Bronze Sand Castings, A.S.T.M. Designation B148-52.

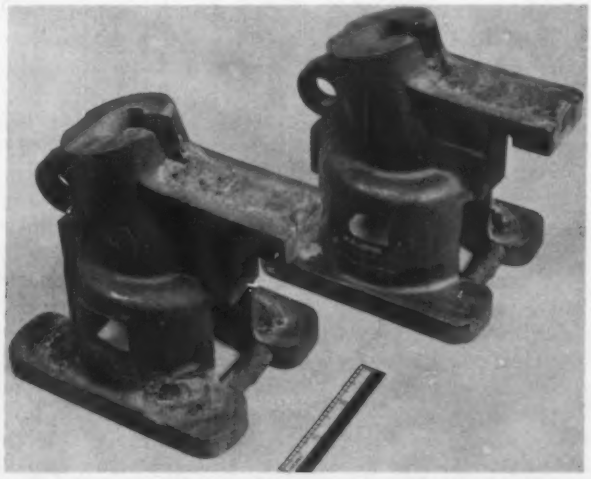


Fig. 14 — Welded high strength yellow brass castings.

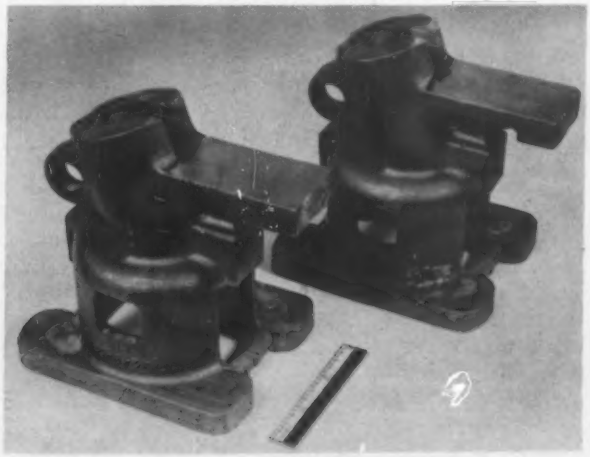


Fig. 15 — Welded high strength yellow brass castings after removal of weld flash from tongues.

MOLDING AND CORE SAND HIGH TEMPERATURE STRENGTH TESTING

A New Approach

by R. W. Heine, J. S. Schumacher and E. H. King

ABSTRACT

A method of testing is described using the dilatometer which shows how compressive strength changes with time of exposure to elevated temperatures. A hollow cylindrical sand specimen is used that has a heating rate equivalent to that obtained in sand layers of similar thickness adjacent to the mold-metal interface. The strength vs. time of exposure curves for molding and core sand is shown and related to their behavior in casting. The variables of clay content and type and moisture content in molding sand are investigated by this method. Comparison is made of the behavior of new and used sand mixtures. The testing method provides a new tool for revealing the behavior of sands during casting of the metal.

INTRODUCTION

A method of studying the change of the compressive strength property of a molding or core sand during heating such as occurs when molten metal is cast against the sand is offered. The elevated temperature properties of foundry sands have been studied under conditions approaching equilibrium where a sample is heated to a certain temperature, held long enough at that temperature to approach equilibrium and then tested. Most of the past studies of high temperature sand properties reported in the literature have been of this type. A reference[1] presents the results of this type of a study by the authors, and other references[2-16] report the work of others who have also used this method.

R. W. HEINE is Prof. of Met. Engrg., Dept. of Mining and Met., University of Wisconsin, Madison, J. S. SCHUMACHER is Vice-Pres. and E. H. KING is Pres., The Hill & Griffith Co., Cincinnati, Ohio.

Objection to this method of testing has been voiced by a number of researchers.[17,18] It is frequently stated that a method of testing should be used that involves rapid heating of the sand sample at rates such as occur in the sand when molten metal is poured into a mold. Such a testing method is presented.

TESTING METHOD

The sample employed is a hollow cylinder 2.0 in. long with $1\frac{1}{8}$-in. O.D. and 0.50 in. I.D. Wall thickness of the sand is thus $\frac{5}{16}$-in. It is double-end rammed three times using a rammer of the type, shown on p. 108 (Fig. 47) of the AFS FOUNDRY SAND HANDBOOK. The specimen tube is shown schematically in Fig. 1. Figure 1 shows a 0.500 in. D. steel rod supported vertically by pin *D* and two centering steel discs *A* and *B*. Disc *A* and pin *D* are placed in position first. The rod and the specimen tube are then positioned.

Sand is then charged into the annular space between the rod and the tube and uniformly distributed. Centering disc *B* is then positioned and pushed down onto the sand until it binds. Pin *D* is removed and rod C is pushed downward until flush with the top of disc *B*. The post is then placed under the rammer and rammed three times. The specimen tube is inverted and rod *C* is withdrawn before the specimen is stripped from the tube.

The sample is then placed in the dilatometer furnace held at some preselected temperature. An own-atmosphere hood shrouds the sample. The hollow sample is seated on a vented ceramic disc so that moisture and gases may pass from the heated O.D. into the hollow center and cut through the

vented disc. This simulates the movement of gases away from the mold-metal interface toward the interior of the mold (or core). The vented disc is shown as part of the setup in Fig. 3.

Compressive Strength

A series of the specimens is broken after increasing time intervals of exposure to the elevated temperature of the dilatometer. For example, with the furnace at 1750 F (954 C), a series of samples is tested for compressive strength after a time interval in the furnace from 20 sec to 10 min. The results permit a graph, such as Fig. 2, to be constructed relating compressive strength of the sand to time of exposure in the furnace.

The hot compressive strength and time of rupture data are plotted as in Curve *A* in Fig. 2, which

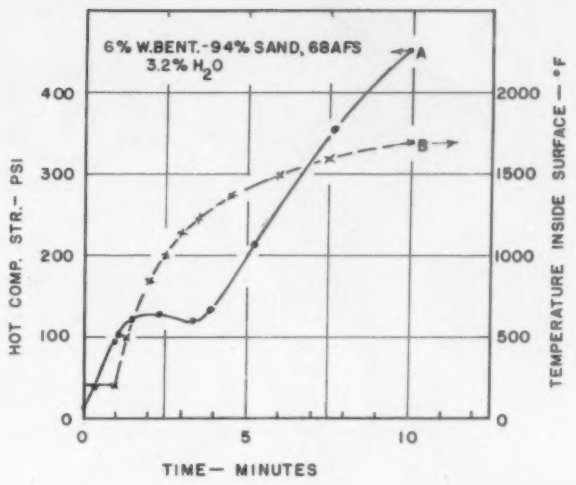


Fig. 2 — Hot compressive strength vs. time in the furnace, and temperature at inside surface vs. time in the furnace for a furnace temperature of 1750 F (954 C).

shows the change of compressive strength with the time of a 6 per cent W. bentonite–94 per cent silica sand mixture with 3.2 per cent moisture exposed to a furnace temperature of 1750 F (954 C). Also shown in Fig. 2 is the rise in temperature with time in the furnace of the inside surface of the hollow specimen at the midpoint of its length, curve *B*. The setup for determining the temperature-time curve is illustrated in Fig. 3.

The hot compressive strength of the sand, and the temperature at the I.D. at any moment of time after the sample is placed in the furnace, is then established in Fig. 2. For instance, 2 min after the specimen is placed in the furnace, the hot compressive

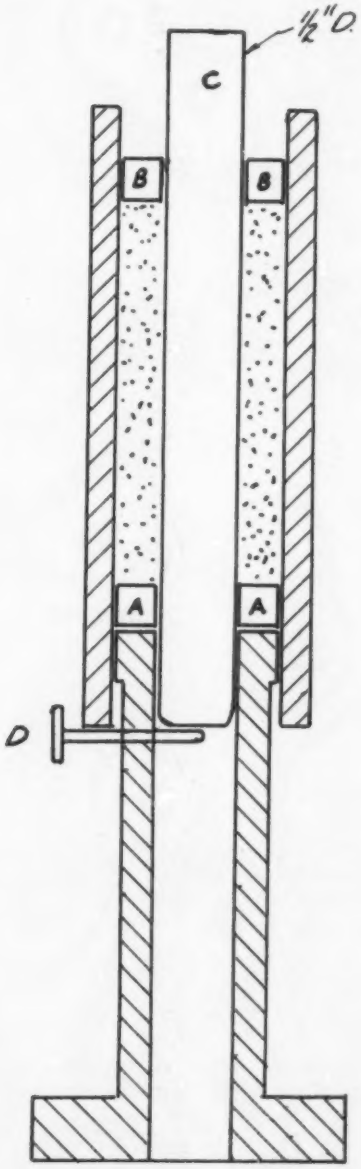


Fig. 1 — Schematic drawing of modified ramming post and sleeve for ramming hollow specimens.

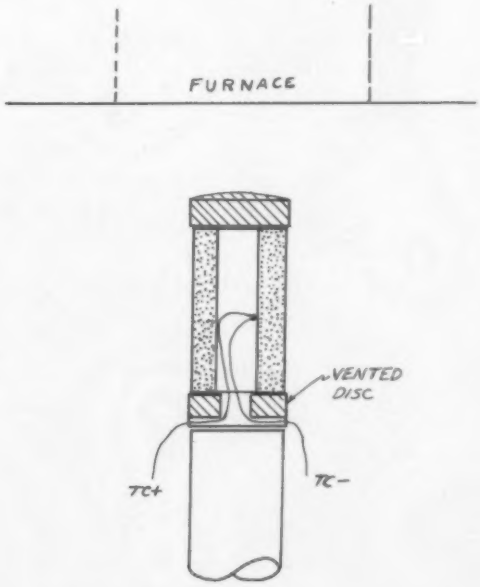


Fig. 3 — Location of thermocouple in hollow specimen for determining temperature of inside surface as a function of time in the furnace.

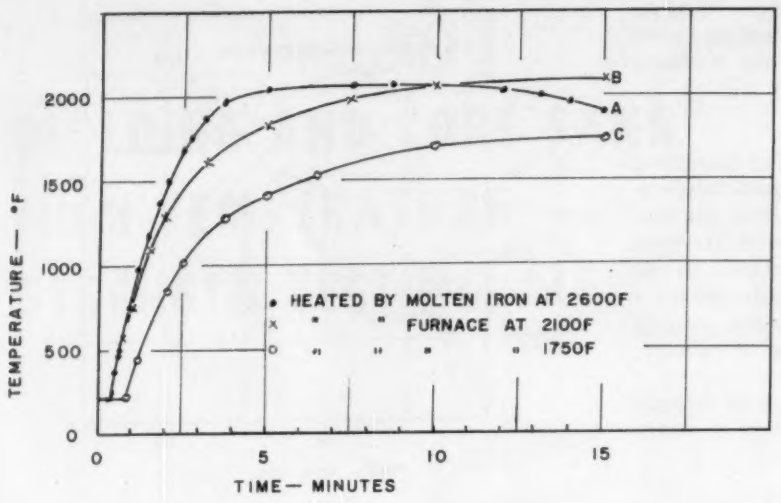


Fig. 4 — Temperature curve of inside surface of hollow specimen vs. time after casting iron around the sample. Curves of temperature vs. time after placing a sample in the furnace at a temperature of 2100 F (1149 C) and 1750 F (954 C) are also shown, for comparison.

strength of the sample is 125 psi and the temperature at the I.D. wall is 850 F (454 C). The plateau in curve *A* at one to 3 min corresponds to the dry compressive strength of the sand. Moisture is evaporated from the sample during the first one min in the furnace, as shown by the temperature curve plateau at 212 F (100 C).

Compressive strength rises from the green strength to the dry strength level during this period. The dry compressive strength level prevails until temperature at the I.D. rises above about 1200 to 1300 F (649-704 C) in about 3.5 to 4.0 min. Beyond this time and temperature, hot compressive strength develops in an increasing amount as temperature and time increase. Hot compressive strength develops mainly in the temperature range 1200 to 1800 F (649-982 C) for bentonite bonded sands, according to the equilibrium method of study.

Thus, curve *A* in Fig. 2 shows a transition from green strength to dry strength to hot strength with increasing time of exposure to high temperature. This transition is predictable from equilibrium high temperature testing of simple sand-clay-water mixture, and could be shown from these data by plotting the data of Fig. 2 as hot compressive strength vs. temperature. This is not done here, as the curve is well known.

SPECIMEN HEATING RATE

The temperature time curve, shown in Fig. 2, provides the rate of heating of the inside surface of the sample for a furnace temperature of 1750 F (954 C) (rate is actually the slope of the curve at any instant). A higher furnace temperature would result in more rapid heating of the sample. It is important to know whether a furnace temperature could be selected that would cause the sample to heat as rapidly as it would if molten metal were cast around it in some specific casting size. This was investigated by using the hollow test specimen as a core in a green sand mold.

The casting consisted of a cylinder of iron 1⅝-in. in thickness by 4¾-in. in diameter weighing about 7 lb. The test specimen was placed vertically in the mold at the center of the cylinder of iron. This particular size of casting was used, as it was calculated that it could take about 10 min for the center of the casting, i.e., the specimen location, to cool through the final eutectic solidification temperature of gray cast iron poured from 2600 F (1426 C). A heating curve at the inside surface at the point, shown in Fig. 3, was again determined.

The temperature time curve is shown in Fig. 4. The heating curve *A*, for the specimen heated by casting it in iron, is compared with the heating curves of specimens exposed to the dilatometer furnace at temperatures of 2100 F (1149 C), curve *B*, and 1750 F (954 C), curve *C*. The specimen heating curves for the 2100 F (1149 C) furnace temperature, and the specimen cast in iron, are seen to follow closely together. The difference in temperature at a given time is small up to about 1200 F (649 C). At higher temperatures the temperature difference increases, and then decreases to a minimum about 10 min after pouring the casting or placing the sample in the furnace.

In any event, the two heating curves are sufficiently close to each other so that the two heating conditions should produce equivalent changes in high temperature properties. One may also observe in Fig. 4 that the temperature at the I.D. of the sample does not drop below the eutectic temperature of the iron until more than 10 min after pouring the iron. These experiments demonstrate that a dilatometer furnace temperature can be selected which will produce a specimen heating rate or temperature-time curve, similar to that caused by a molten iron casting.

Obviously, many combinations of casting size and shape and dilatometer furnace temperature could be studied in this way. Furthermore, the wall thickness of the hollow specimen could be reduced. However, these changes do not appear necessary, for reasons which will become evident.

Sand Heating Rates

Other examples of heating rates of sand are available from the literature. A reference[19] provides heat-

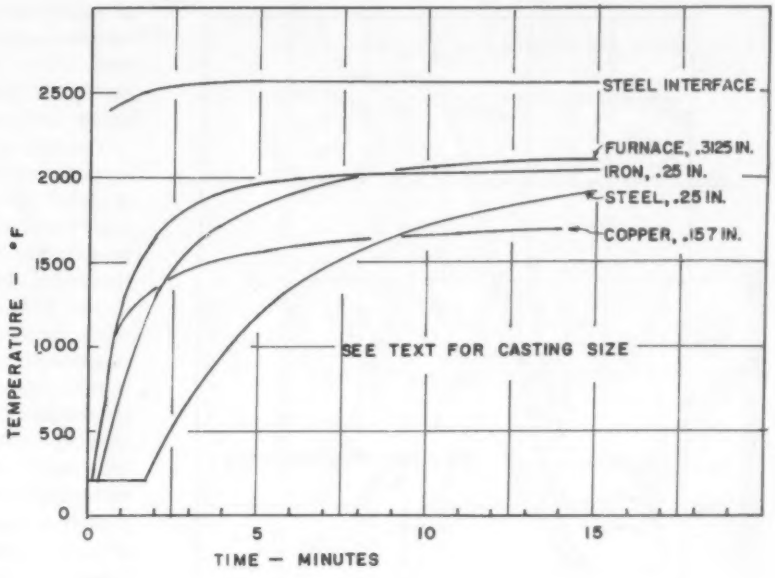


Fig. 5 — Heating curves of molding sand at the indicated distance from the mold surface when steel, gray iron and copper are cast against the sand (see text for details). Comparison is made with heating curve *F* of the hollow sample in the dilatometer at 2100 F (1149 C).

ing curves at the mold interface and 0.25 in. in from the interface when a 7 in. x 7 in. square section of steel bar is cast in green sand. These heating curves are marked *SI* (steel interface-mold surface) and S (Steel) 0.25 in from surface in Fig. 5. Another reference[20] shows heating curves for a point 0.25 in. from the mold surface where gray iron is cast in a 7 in. x 7 in. square bar; the curve is marked I (Iron) 0.25 in. in Fig. 5.

Another reference[21] provides a heating curve for a distance 0.157 in. from the mold surface of a copper casting. This curve is marked C (Copper) 0.157 in. on Fig. 5. For comparison, Fig. 5 also shows the heating curve *F* (Furnace), for the inside surface of the hollow specimen ($\frac{5}{16}$-in. wall thickness) placed in the dilatometer at 2100 F (1149 C). These curves all demonstrate finite heating rates which are of a similar order of magnitude. They cannot be expected to be identical, but the point is made that if it were necessary a furnce temperature and hollow specimen wall thickness could be chosen to simulate the heating curve of sand caused by casting metal against it. This is an unnecessary refinement in method as subsequent sections reveal.

The difficulty of measuring sand surface temperature, both in actual molds and on the test specimen, makes it impractical to consider heating curves of these surfaces. However, they must be also similar, since the heat will only be transferred in a given time interval if the temperature differences, surface to interior point, are equivalent in magnitude.

DILATOMETER FURNACE TEMPERATURE

The effect of dilatometer furnace temperatures of 1200, 1500, 1750 and 2250 F (649, 815, 954 and 1232 C) on the hot compressive strength-time curve is shown in Fig. 6. The sand is a mixture of 6 per cent western bentonite-94 per cent silica sand of 68 AFS, 4 screen type with 2.6 per cent H_2O. At 1200 F (649 C), the strength rises from the green strength level to the dry compressive strength level, but no significant increase occurs from hot strength. At 1500 F (815 C), hot strength above the dry strength level begins after the sample has been in the furnace for about 4.5 min. At 1750 F (954 C), hot strength begins to develop after the sample is in the furnace about 3.5 min.

At the latter two temperatures, hot strength of the sand is still increasing after 10 min in the furnace. At 2250 F (1232 C), hot strength begins to develop after about 1.25 min in the furnace, reaches a peak after 2.5 min and then decreases. The decreasing strength is caused by fusion of the clay at the higher

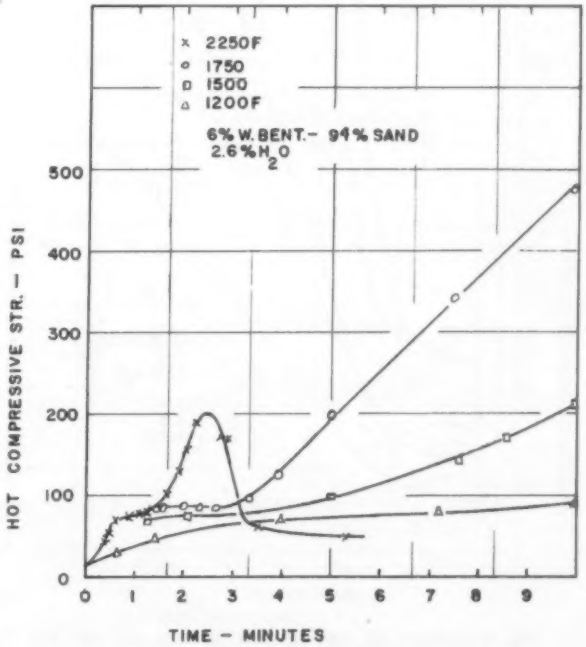


Fig. 6 — Effect of dilatometer furnace temperature on the hot compressive strength vs. time in the furnace curve for a 6 per cent western bentonite - 94 per cent 68 AFS silica sand, 2.6 per cent H_2O mixture.

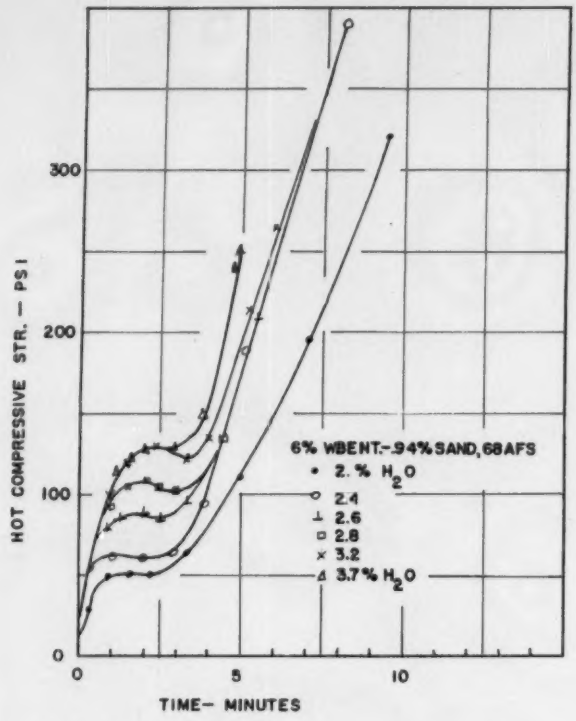


Fig. 7 — Effect of moisture content on hot strength vs. time in the furnace curve of a 6 per cent western bentonite - 94 per cent sand mixture.

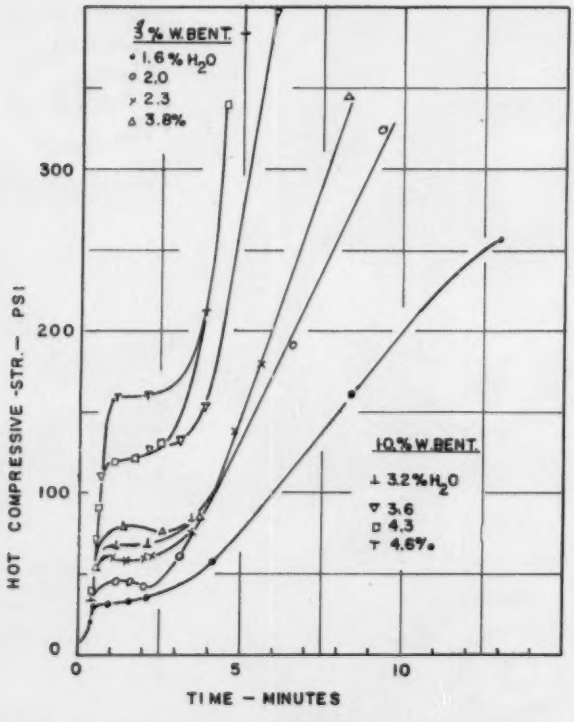


Fig. 8 — Effect of varying clay content on the hot strength vs. time in the furnace curve. Mixtures containing 3 per cent western bentonite and 10 per cent western bentonite may be compared with 6 per cent western bentonite in Fig. 7.

temperatures. Fusion occurs to the point where the samples no longer fracture but simply flow under load. Thus the strength-time, in the furnace curves in Fig. 6, follow relationships expected from equilibrium studies.[1]

The selection of a particular furnace temperature for heating the specimen is best made on the basis of what particular property change with time is under study, rather than on the basis of attempting to produce some particular rate of heating of the specimen. In the case of the higher temperatures, above 1750 F (954 C), a mechanical problem arises with the loading rate of the specimen. The changes in strength occur so rapidly during the first ½ min to 2 min that it becomes difficult to manipulate the dilatometer within the time required. For that reason, a furnace temperature of 1750 F (954 C) was most commonly used, except where special effects were studied at higher or lower temperatures.

Deformation of the sand could be considered here, too. However, since it follows expected behavior based on temperature, it will not be considered.

MOISTURE AND CLAY CONTENT EFFECT

The effect of moisture variation on the hot strength — time curve for a 6 per cent western bentonite-94 per cent silica sand mixture is summarized in Fig. 7. Dry compressive strength level is, of course, expected to vary with moisture in the sand in the range indicated. Hot compressive strength after a given interval in the furnace is also higher at higher moisture contents. The effect of higher and lower clay contents, 10 and 3 per cent western bentonite, is compared with 6 per cent western bentonite in Figs. 7 and 8 again with moisture variable. The lower clay contents produce lower strength vs time curves and the higher clay content raises the curves as expected. Similar results were obtained for southern bentonite.

CLAY TYPE EFFECT

Figure 9 compares hot strength-time curves for 6 per cent western bentonite, 6 per cent southern bentonite and 15 per cent fireclay bonded mixtures using a furnace temperature of 1750 F (954 C). The fireclay appears to behave differently than the bentonite bonded sand, since it shows no dry compressive strength level in the curve. However, this is to be expected on the basis of the equilibrium studies reported.[1]

CORE SAND

Core sands were also studied using this method. However, the specimens were first baked and cooled to room temperature to develop the normal core oil bond. The data for one of the mixtures studies are shown plotted in Fig. 10. The mixture contained 1.75 per cent oil, 2.0 per cent cereal, 4 per cent water and 68 AFS 4 screen silica sand. As-baked, the room temperature compression strength was 1000 psi. Furnace temperatures of 1200 F (649 C) and 1750 F (954 C) were used. Hot deformation and compressive strength were measured. Figure 10 shows rapid decrease of strength to a less than 25 psi in less than 2 min in the furnace.

The core specimens also show a large increase in deformation at the time of the minimum strength. This is due to softening of the core oil bond and distillation of the volatile fraction during this time interval. Distillation may be observed, and gases coming from the sample burst into flame on coming into contact with air at the exit to the own atmosphere shroud after the core specimen is in the furnace for 17 sec at a furnace temperature of 1750 F (954 C). The minimum strength of 22 psi at 2 min is followed by a rise due to coking of the core oil bond when distillation ceases.

The end of distillation and the coking bond causes hot deformation to decrease from its maximum. With continued time in the furnace at 1200 F (649 C), the strength drops to zero psi due to oxidation of the carbon coke bond. However, at 1750 F (954 C) hot strength is maintained in this mixture from the ash of the oil and cereal and the approximately 0.5 per cent AFS clay content of the base sand. These results illustrate the importance of selecting proper furnace temperatures. At 1200 F (649 C), the coke bond is destroyed by oxidation but no high temperature fusion bond is developed. The same results are obtained at 1000 F (539 C), but the time is extended.

At 1750 F (954 C), a fusion bond develops from fusible inorganic materials in the sand. Lower percentages of oil and cereal lower the strength level of the coke bond as would be expected and also the fusion bond. The authors believe these results explain the behavior of cores and core sand molds in comparison with molding sands during casting operations. This is especially true if the hot strength-time curve of molding sands containing carbonaceous materials is compared with the curves for core sands.

FOUNDRY MOLDING SAND

The hot strength-time curves for two foundry sands used for green sand molding are shown in Fig. 11. The analysis of these sands is given in the table. Many other sands were tested. The two listed in the table simply illustrate a lower and higher level of hot strength vs. time curve for a furnace temperature of 1750 F (954 C). It should be remembered that these curves are for specimens rammed to about 90-92 mold hardness. The principle points to be observed from these curves are that they behave the same as the new sand mixtures tested, and that the lower strength-time curve is not as high as that of some core sand mixtures once the dry strength level is reached.

Core sands are, of course, easier to ram to full density than are molding sands under foundry conditions. The lower curve in Fig. 11 shows a hot strength plateau for sand *B* at 34 psi. But this is at 92 mold hardness. Dry compressive strength in the table is shown to be 41 psi. This sand appears to have too low a strength level if it is to be used in molds at the 80 mold hardness level. It might be expected to cut or wash during pouring and to show dirt in the casting. The low strength level is due to the cellulose content of the sand.

This example shows how a sand may have a lower hot strength plateau (called hot-dry compressive strength) than might be expected from the commonly determined dry compressive strength test. This effect may be caused by excessive carbonaceous material in the sand for the percentage of clay present.

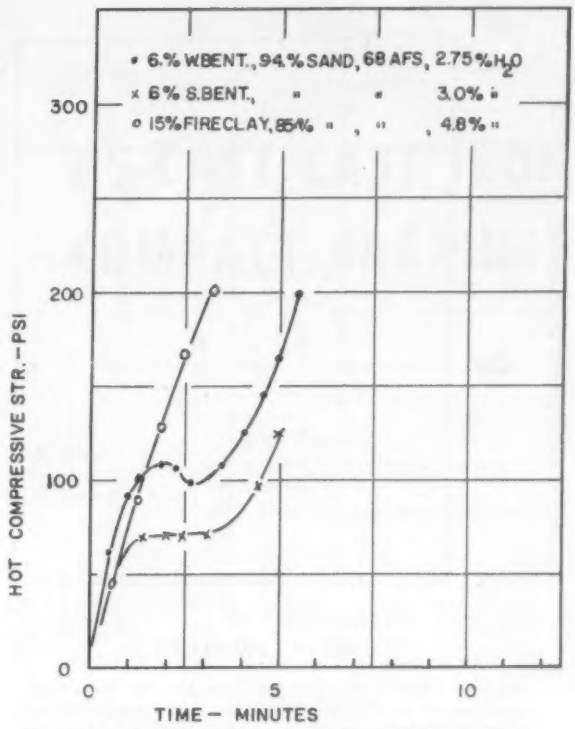


Fig. 9 — Effect of clay type on shape of hot strength vs. time in the furnace curve for sands containing 6 per cent western bentonite, 6 per cent southern bentonite and 15 per cent fireclay, respectively.

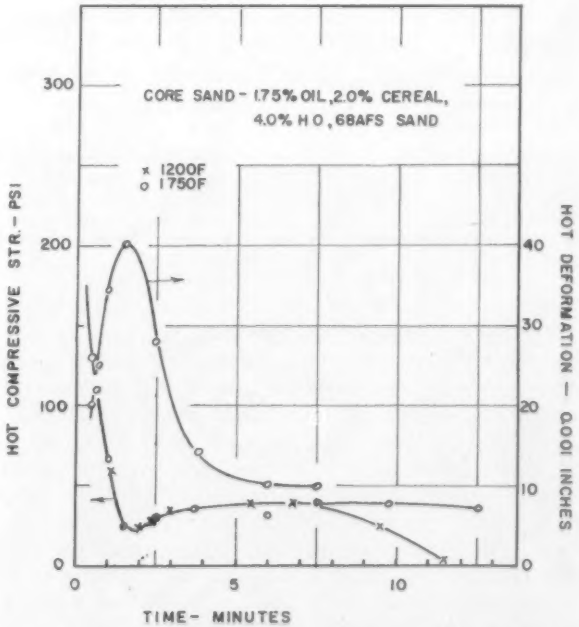


Fig. 10 — Effect of time of exposure to a furnace temperature of 1200 F (649 C) and 1750 F (954 C) on hot strength and deformation of hollow cores and specimens. Baked strength of the hollow cores at room temperature was 1000 psi.

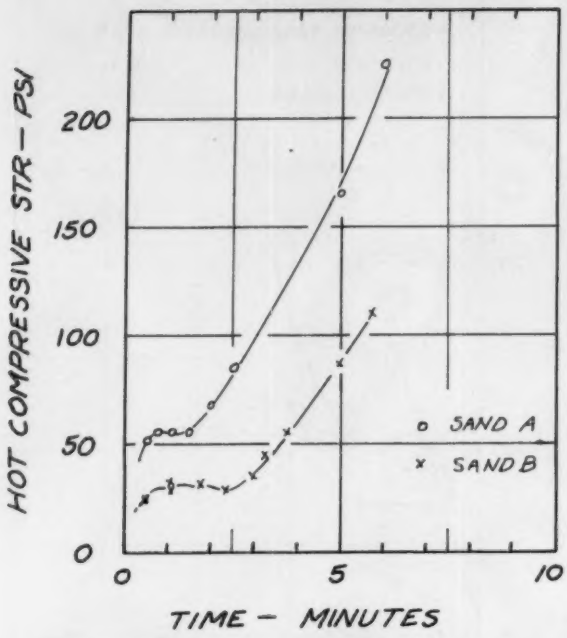


Fig. 11 — Effect of time of exposure to a furnace temperature of 1750 F (954 C) on hot strength of two different foundry molding sands whose analyses are given in the table.

ANALYSIS OF TWO FOUNDRY SANDS USED FOR HOT STRENGTH-TIME TESTS

	Sand A	Sand B
AFS no.	63	65
AFS Clay, %	10.6	14.6
Adjusted Clay, %	6.45	9.45
Effective Clay, %	6.0	6.0
H_2O, %	4.0	4.8
GCS, psi	14.0	13.8
DCS, psi	60.5	41.0
1750 F (954 C), volatile matter, %	3.71	4.56
Fixed Carbon, %	4.39	4.18
Total Carbon, %	8.10	8.74
Cellulose in Sand, %	0.56	1.65
Sea coal	balance	balance
Bond	W. Bent.	W. + S. Bent.
Metal Poured	Gray iron	Gray iron

The three ram specimens used in this work had a 90-92 mold hardness. The effect of ramming on the hot strength-heating time curve of molding sands was studied. The results will not be considered in detail in this paper. It was found generally, however, that hot strength in specimens of 70 mold hardness is about 10 to 25 per cent of that at 90-92 mold hardness, being closer to 10 per cent when the sand was on the dry side and to 25 per cent when the sand was on the wet side. At 80 mold hardness, the hot strength was 25 to 50 per cent of the value at 90 to 92 mold hardness, moisture again being a major factor in the range.

SUMMARY

A method of testing and a means of graphical presentation of the hot strength-time and temperature relationships in molding and core sands has been described. The hollow specimen used for testing has been demonstrated to have heating rates in the dilatometer, which are much like those encountered in the first 0.25 in. sand layer below the surface of molds cast with steel or gray iron. Molding sand and core sand mixtures have been shown to develop similar hot-dry compressive strength properties, and may therefore function equally well in producing certain castings. The testing method may be used to show the effects of carbonaceous additives, various types of bonding agents and for core and molding sands, although the main purpose of this paper has been to describe the testing procedure and a few of the useful principles uncovered.

REFERENCES

1. R. W. Heine, J. S. Schumacher, W. F. Shaw and E. H. King, "Ramming and Clay Content Effect on Hot Compression Strength of Molding Sand," AFS Transactions, *vol. 68*, p. 304 (1960).
2. R. E. Morey, C. G. Ackerlind and W. S. Pellini, "Effect of Binders and Additives on the High Temperature Properties of Foundry Sands," AFS Transactions, *vol. 60*, p. 266 (1952).
3. R. E. Morey and C. G. Ackerlind, "A Study of the Effect of Various Binders and Additives on Hot Strength of Molding Sands," AFS Transactions, *vol. 58*, p. 411 (1950).
4. R. G. Thorpe, A. E. Riccardo, P. L. Widener and P. E. Kyle, "Investigation of Properties of Steel Sands at Elevated Temperatures," AFS Transactions, *vol. 60*, p. 197 (1952).
5. H. W. Dietert and E. E. Woodliff, "The Hot Strength and Collapsibility of Foundry Sands," AFA Transactions, *vol. 47*, no. 2, p. 349 (Dec. 1939).
6. H. L. York, "Report of Progress of Sand Research on Steel Sand Mixtures at Elevated Temperatures," AFA Transactions, *vol. 47*, no. 4, p. 809 (June 1940).
7. D. C. Williams, "High Temperature Sand Testing," Sixth Annual Progress Report, AFA Transactions, *vol. 54*, p. 489 (1946).
8. H. W. Dietert and R. L. Doelman, "Behavior of Molding Materials in Own Atmosphere at Elevated Temperatures," AFA Transactions, *vol. 54*, p. 610 (1946).
9. D. C. Williams, "High Temperature Sand Testing," Fifth Annual Progress Report, AFA Transactions, *vol. 53*, p. 175 (1945).
10. D. C. Williams and P. E. Kyle, "Seventh Annual Report on Investigation of Properties of Steel Sands at Elevated Temperatures," AFA Transactions, *vol. 55*, p. 607 (1947).
11. J. P. Fraser and P. E. Kyle, "Eighth Annual Report on the Investigation of Properties of Steel Sands at Elevated Temperatures," AFS Transactions, *vol. 56*, p. 345 (1948).
12. R. G. Thorpe, H. Robinson, P. J. Wisniewski and P. E. Kyle, "Twelfth Annual Report on the Investigation of Properties of Steel Sands at Elevated Temperatures," AFS Transactions, *vol. 61*, p. 96 (1953).
13. "Heat Penetration into Foundry Molds," *American Colloid Co. Bulletin* (1943).
14. R. G. Thorpe, P. E. Kyle and J. P. Fraser, "Tenth Annual Report on the Investigation of Steel Sands at Elevated Temperatures," AFS Transactions, *vol. 58*, p. 133 (1950).
15. H. W. Dietert, Foundry Sand Practice, p. 34, 54-61 (1950).
16. R. G. Thorpe, O. O. Eberlein, R. C. Waugh and P. E. Kyle, "Investigations of Properties of Steel Foundry Sands at Elevated Temperatures," AFS Transactions, *vol. 62*, p. 43 (1954).
17. W. B. Parkes, "Hot Strength of Clay-Bonded Sands," *Foundry*, p. 113 (Dec. 1955).
18. G. J. Vingas and A. H. Zrimsek, "Is a New Concept Needed for Hot Sand Properties," Modern Castings, *vol. 38*, no. 5, p. 33 (Nov. 1960).
19. W. S. Pellini, H. F. Bishop and F. A. Brandt, "Solidification of Steel Against Sand and Chill Walls," AFS Transactions, *vol. 59*, p. 435 (1951).
20. R. P. Dunphy and W. S. Pellini, "Solidification of Gray Iron in Sand Molds, AFS Transactions, *vol. 59*, p. 431 (1951).
21. R. W. Ruddle, "The Solidification of Castings," *Monograph No. 7*, Institute of Metals.

AS-CAST CAST IRON COMPACT GRAPHITE

Progress Report
Malleable Division
Sponsored By
AFS Training and Research Institute

by R. W. Heine and T. W. Mueller

ABSTRACT

This report presents a brief summary of work at the University of Wisconsin, sponsored by the AFS Training and Research Institute under the direction of the AFS Malleable Division, with attempting to produce compact graphite in the as-cast structure of cast irons. The work was aimed at studying the effect of additions to the melt and variations in base composition of the iron.

PROCEDURE

Melting practices employing an induction furnace were used, as in previous work, in preparing 100 lb heats of iron.[1,2] After melting down, heating to 2800 F (1538 C), and holding, the iron was allowed to cool to 2750 F (1510 C) with power off. The addition was made by plunging the material wrapped in sheet steel into the molten iron. Pouring into molds was then done at 2700 F (1482 C). The 100 lb heats listed in Table 1 were made in this way. Nine lb heats were made in the same way in a small induction furnace. From these heats, 1⅞-in. D bars could be poured. Since these bars show the same fracture as the 2 x 2 x 8 in. bar, no change in interpretation is necessary. Heats made in the small induction furnace are listed in Table 2.

FRACTURE

The terms gray, mottled and white fracture are well understood. However, in this work two additional fracture types were obtained that need to be explained. One of lesser importance is the white rim-gray center fracture, shown in Fig. 1. The other is a fracture which is named compact-graphite mottle fracture. The appearance is that of a white fracture, but close examination reveals many fine mottle spots of pin-point size. This fracture is shown in Fig. 2. Metallographic examination of the iron reveals that the mottle is in the form of compact graphite, such as shown in Figs. 3 and 4. The fracture is similar, or perhaps the same, as that of ductile iron in which the eutectic has failed to graphitize during freezing. This fracture will be given the symbol CW, compact graphite mottle-white fracture. The fracture results

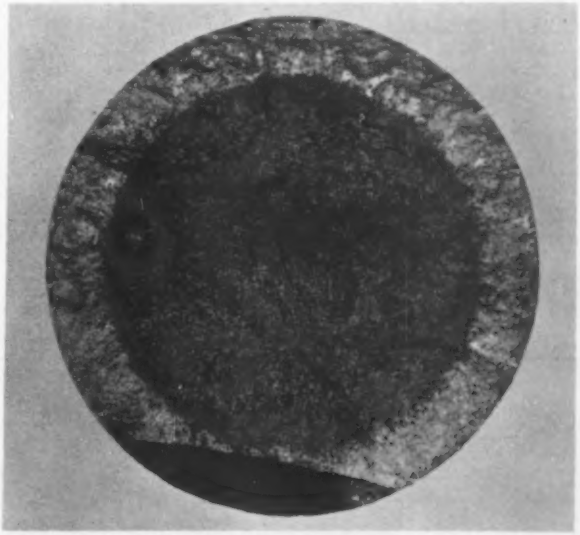


Fig. 1 — Specimen M147. White iron, gray center fracture. 1⅞-in. bar.

R. W. HEINE is Prof. and T. W. MUELLER is Proj. Asst., Dept. of Mining and Met., University of Wisconsin, Madison.

TABLE 1 — HEATS POURED FOR STUDY OF COMPACT GRAPHITE FORMATION (100 LB HEATS)

Heat No.	Analysis, % C	Si	S Orig.	S Final	Addition	Fracture 2 x 2 x 8	Fracture 3 x 3 x 8	Microstructure (Graphite Form)
M 9	2.54*	2.02*	0.050	0.050	0.1 Te	M	M	F, LC
M 10	2.50	2.02	0.050	0.050	0.01 Te	M	G	F, LC
M 11	2.50	2.00	0.050	0.050	0.2 Te	CW	CW	SC
M 15	2.32	1.05	0.051	0.035	None	M	M	SC
M 18	2.32	1.05	0.051	0.040	None	W	W	LC, SC
M 19	4.30	0.20	0.043	0.043	None	IC	IC	SC
M 20	4.30	0.75	0.059	0.059	None	G	G	F
M 21	4.30	0.31	0.046	0.046	None	IC	IC	Not Observed
M 22	4.30	0.42	0.049	0.049	None	IC	IC	Not Observed
M 23	2.32	1.05	0.051	0.035	None	M	M	SC
M 24	2.38*	0.98*	0.051	0.025*	None	M	M	Not Observed
M 25	3.90	1.70	0.044	0.044	0.1 Te	M	M	F, LC
M 26	3.60	1.70	0.044	0.044	0.1 Te	M	M	LC, SC
M 27	3.90	1.70	0.044	0.044	0.01 Te	M	G	LC
M 28	3.70*	1.70	0.044	0.030*	None	G	G	Type A Flake
M 29	3.90	1.70	0.044	0.025	0.01 Te	G	G	LC, F
M 30	3.94*	1.70	0.044	0.020*	0.02 Te	IC	G	S, SC
M 31	3.90	1.70	0.044	0.020	0.01 Te; 0.02 B	G	G	F
M 32	4.00	1.30	0.044	0.020	0.01 B	G	G	F
M 33	4.00	1.30	0.044	0.020	0.02 B	G	G	F
M 34	4.03	1.70	0.044	0.020	0.04 Te	IC	IC	S, SC, F
M 35	2.68	1.80	0.050	0.020	0.04 Te	M	M	S, SC
M 36	4.08	1.55	0.044	0.020	0.04 Te; 0.004 Mischmetal	M	IC	S, SC, F
M 37	2.68	1.85	0.050	0.020	0.04 Te; 0.02 B	M	M	SC
M 38	2.68	1.85	0.050	0.020	0.04 Te	M	M	SC
M 39	2.68	1.85	0.050	0.020	0.04 Te; 0.02 B	M	M	SC
M 40	2.68	1.85	0.050	0.018*	0.04 Te; 0.02 B	M	M	LC
M 41	2.72*	1.85*	0.050	0.020*	0.04 Te; 0.02 B	M	M	LC
M 42	2.64*	1.83*	0.050	0.020*	0.02 Bi; 0.02 B	M	G	F, SC
M 43	2.68	1.70	0.050	0.015	0.02 B; 0.04 Bi	M	G	F, SC
M 44	2.68	1.70	0.050	0.015	0.02 B; 0.04 Te	W	W	
M 45	2.52	2.05	0.050	0.015	0.04 Bi; 0.02 B	M	G	F, LC
M 46	2.52	2.05	0.050	0.015	0.04 Te; 0.02 B	M	M	SC
M 47	2.52	2.05	0.050	0.015	0.04 Te	M	M	SC, LC
M 48	2.52	2.25	0.050	0.018*	0.04 Te; 0.02 B	M	M	SC, F
M 49	2.52	2.25	0.050	0.014*	0.04 Te	M	M	F, LC
M 52	2.50*	2.35*	0.050	0.018*	0.03 Te; 0.68 Ce	CW	CW	SC, S
M 58	2.52	2.25	0.050	0.018*	0.04 Te	M	M	SC, S
M 59	2.52	2.25	0.050	0.018	0.13 Ce	CW	CW	SC, F, S
M 60	2.52	2.25	0.050	0.018	0.26 Ce	CW	CW	SC, S
M 63	2.36*	1.50*	0.050	0.015*	0.25 Ce	W	CW	SC, S

IC — Inverse Chill
W — White
M — Mottled
G — Gray
CW — Compact Graphite Mottle, White Fracture
SC — Stubby Compact Graphite
LC — Loose Compact Graphite
S — Spherulitic Graphite
F — Flake Graphite
* — Commercial Laboratory Analysis

TABLE 2 — HEATS POURED FOR STUDY OF COMPACT GRAPHITE FORMATION (9 LB HEATS)

Heat No.	Analysis, % C	Si	S Orig.	S Final	Addition	Fracture	Microstructure (Graphite Form)
M 70	2.70*	1.17*	0.071	0.036*	0.15 Ce	G	F, SC, S
M 71	2.80*	2.33*	0.071	0.035*	0.36 Ce	CW	SC, S
M 72	2.75	2.25	0.071	0.035	0.14 Ce; 0.1 Te	CW	SC, S
M 73	2.36*	1.61*	0.071		0.21 Ce	G	F, SC

(continued on next page)

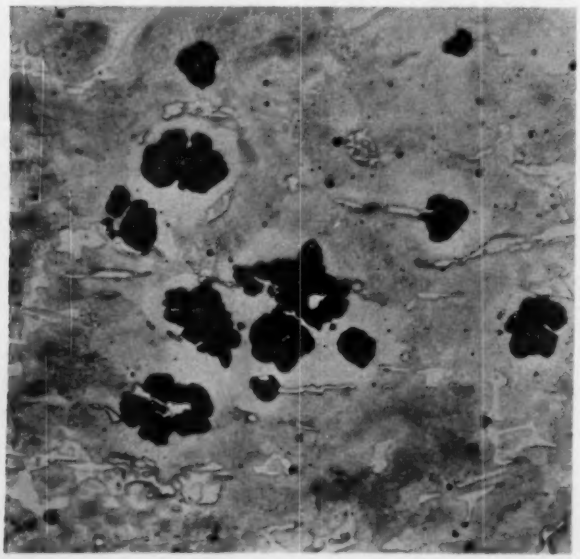
TABLE 2 — HEATS POURED FOR STUDY OF COMPACT GRAPHITE FORMATION (9 LB HEATS) *(continued)*

Heat No.	Analysis, % C	Si	S Orig.	S Final	Addition	Fracture	Microstructure (Graphite Form)
M 74	2.48*	1.60*	0.071		0.40 Ce	CW	
M 75	2.45	1.55	0.071		0.39 Ce (Late Si addition)	G	F, SC
M 76	2.45	1.55	0.071		0.59 Ce	CW	
M 77	2.45	1.55	0.071		0.84 Ce	CW	SC, S
M 78	2.43	2.25	0.071		0.18 Ce	G	F
M 79	2.60*	2.25	0.071		0.44 Ce	CW	SC
M 80	2.54*	2.25	0.071		0.60 Ce	CW	SC
M 81	2.55	2.25	0.071		0.78 Ce	CW	SC, S
M 82	2.50	1.50	0.071		0.31 Ce	G	F, SC
M 83	2.50	2.25	0.071		0.31 Ce	G	F, SC
M 84	2.50	2.25	0.071		0.30 Mischmetal	G	F, SC
M 85	2.50	2.25	0.071		0.48 Mischmetal	CW	SC
M 86	2.50	2.25	0.071		0.31 Mischmetal	G	F, SC
M 87	2.50	2.25	0.071		0.31 Mischmetal	G	F, SC
M 88	2.50	2.25	0.071		0.39 Mischmetal	G	SC, F
M 89	2.50	2.25	0.071		0.70 Mischmetal 0.04 Te	M	SC
M 90	2.58*	2.25*	0.071		0.43 Mischmetal	CW	SC
M 91	2.50	2.25	0.071		0.30 Mischmetal 0.01 Te	White rim	SC, F
M 92	2.50	2.25	0.071		0.30 Mischmetal 0.05 Te	White rim	SC, F
M 93	2.50	2.25	0.071		0.30 Mischmetal 0.1 Te	CW	SC, S
M 94	2.50	2.25	0.071		0.50 Mischmetal 0.01 Te	CW	SC
M 95	2.50	2.25	0.071		0.50 Mischmetal 0.05 Te	CW	SC
M 96	2.50	2.25	0.071		0.50 Mischmetal 0.1 Te	CW	SC
M 97	2.50	2.25	0.071		0.70 Mischmetal 0.01 Te	CW	SC
M 98	2.50	2.25	0.071		0.68 Mischmetal 0.05 Te	CW	SC, S
M 99	2.50	2.25	0.071		0.72 Mischmetal 0.1 Te	CW	SC
M 111	2.39	2.08	0.071		0.7 Mischmetal 0.1 Te	W	
M 112	2.59	2.08	0.070		0.7 Mischmetal 0.1 Te	CW	SC
M 114	2.58*	2.05	0.070		0.7 Mischmetal 0.1 Te	CW	SC
M 115	2.80*	2.09*	0.070		0.7 Mischmetal 0.1 Te	CW	SC
M 116	2.99	2.08	0.070		0.7 Mischmetal 0.1 Te	CW-G	SC, F
M 117	3.19	2.08	0.070		0.7 Mischmetal 0.1 Te	G	SC, F
M 118	3.44	2.08	0.070		0.7 Mischmetal 0.1 Te	G	F, SC
M 120	3.84	2.08	0.070		0.7 Mischmetal 0.1 Te	G	F, SC
M 121	2.30	2.08	0.070		0.7 Mischmetal 0.1 Te	CW	SC
M 122	2.08	2.08	0.070		0.7 Mischmetal 0.1 Te	CW	SC
M 123	2.56*	2.40*	0.070		0.7 Mischmetal 0.1 Te	CW	SC
M 124	2.38*	2.57*	0.070		0.7 Mischmetal 0.1 Te	CW	SC
M 127	2.34*	2.77*	0.070		0.7 Mischmetal 0.1 Te	CW	SC, F, S
M 128	2.50	4.00	0.070		0.7 Mischmetal 0.1 Te	CW-G	SC, F
M 129	2.06*	3.00	0.070		0.7 Mischmetal 0.1 Te	CW-W	SC
M 130	2.08	4.00	0.070		0.7 Mischmetal 0.1 Te	CW-G	SC, F, S
M 131	2.13	2.60	0.070		0.7 Mischmetal 0.1 Te	CW-W	SC, S
M 132	2.25	3.00	0.070		0.7 Mischmetal 0.1 Te	CW	SC, F, S
M 133	2.63	2.60	0.070		0.7 Mischmetal 0.1 Te	CW-G	SC, F
M 134	2.50	3.00	0.070		0.7 Mischmetal 0.1 Te	CW-G	SC, F
M 137	2.38*	1.60	0.070		0.7 Mischmetal 0.1 Te	CW	S, SC
M 138	3.20	1.50	0.070		0.7 Mischmetal 0.1 Te	CW-W	SC
M 139	2.40	1.50*	0.070		0.7 Mischmetal 0.1 Te	CW-W	S, SC
M 140	2.80	1.50	0.070		0.7 Mischmetal 0.1 Te	W	
M 141	2.50	1.75	0.070		0.7 Mischmetal 0.1 Te	CW-W	SC
M 142	2.70	1.23	0.070		0.7 Mischmetal 0.1 Te	W	
M 143	2.55	1.35	0.070		0.7 Mischmetal 0.1 Te	CW-W	S, SC
M 144	2.85	1.20	0.070		0.7 Mischmetal 0.1 Te	W	
M 145	2.70	1.35	0.070		0.7 Mischmetal 0.1 Te	CW-W	S, SC
M 146	2.50	2.25	0.070		0.7 Mischmetal 0.1 Te	CW	SC
M 147	2.50	2.25	0.070		0.35 Mischmetal 0.05 Te	CW-G	SC, F
M 148	2.45	1.60	0.070		0.35 Mischmetal 0.05 Te	CW-G	SC, S, F
M 149	2.45	1.60	0.070		0.35 Mischmetal 0.1 Te	CW-G	SC, S, F
M 150	2.45	1.60	0.070		0.7 Mischmetal 0.5 Te	CW-W	SC
M 151	2.45	1.60	0.070		0.45 Mischmetal 0.03 Te	W	
M 152	2.45	1.60	0.070		1.0 Mischmetal	W	
M 153	2.45	1.60	0.070		0.45 Mischmetal 0.01 Te	CW-W	SC, S

W — White
M — Mottled
G — Gray
CW — Compact Graphite Mottle, White Fracture
SC — Stubby Compact Graphite
S — Spherulitic Graphite
F — Flake Graphite
* — Commercial Laboratory Analysis

Fig. 2 — Specimen M52. Compact graphite mottle-white fracture. 3 x 3 x 8 in. casting. 8 ×.

Figs. 3 and 4 — Specimen M52 etched for 15 sec with 2 per cent nital. 3 x 3 x 8 in. casting. 100 ×.



for each heat are recorded in Tables 1 and 2. Cerium is shown to be most effective in producing white iron or compact graphite mottle.

ADDITIONS

The additions used and the base iron compositions studied may be classified:

1. Desulfurized Heats
   a. 0.01 to 0.04 per cent Te additions to base compositions of 1.70 per cent Si and 3.90 per cent C, heats M25 to M31, and M34.
   b. Bismuth, same as (a), heats M32 and M33.
   c. 0.04 per cent Te and 0.02 per cent B additions to base compositions of 1.85 per cent Si and 2.68 per cent C, heats M37 to M41.
2. Cerium Added to Desulfurized Heats
   0.10 to 0.80 per cent Ce additions to base compositions of 2.50 per cent C and 1.50 to 2.25 per cent Si, heats M59, M60 and M63.
3. Cerium added to undesulfurized heats, 0.01 to 0.80 per cent, heats M70 - M83.
4. Mischmetal added to undesulfurized heats, 0.30 to 0.48 per cent added, heats M84 to M88.
5. Mischmetal and tellurium combined, added to undesulfurized iron, 0.30 to 0.72 per cent mischmetal and 0.01 to 0.10 per cent Te added, heats M91 to M99, M111, M112, M114-118, M120-124, M127-134, M137-153.

The effects of these additions on the fracture and type of graphite formed will be discussed.

COMPACT GRAPHITE IN THE AS-CAST CONDITION

Desulfurization

In order to produce compact graphite in the as-cast condition, it was thought that a low sulfur content might be helpful as in ductile iron. To achieve low sulfur irons basic melting practices were used. Basic slags composed of calcium carbide, calcium oxide and calcium fluoride were initially used and

were successful in reducing sulfur from 0.051 to 0.025 per cent. These slags were added to the melt at 2750 F (1510 C), held for 10 min and skimmed off.

Other slags used were composed of calcium oxide, magnesium oxide, sodium carbonate, portland cement, calcium carbide and silica. The basicity was generally kept at 2.3 and the weight about 4 per cent of the charge weight. The slags were added with the cold charge and kept on the molten bath until shortly before pouring. The sulfur was lowered from an original level of 0.051 to 0.015 - 0.025 per cent.

These desulfurizing treatments were applied to heats in both the hypoeutectic and hypereutectic composition ranges. In the hypereutectic region, tellurium additions were made to a base composition of around 3.90 per cent C and 1.70 per cent Si. Metallographic examination showed that in a normally gray freezing composition, tellurium suppressed proeutectic flake graphite precipitation. The graphite present was of lacy and compact type. The compact graphite was generally of stubby to slightly spherodized shape. While 0.01 per cent Te was sufficient to prevent proeutectic flake graphite, it was necessary to add 0.04 per cent Te to produce the best structure. Heat M34 showed the best compact graphite up to that time produced.

In some hypereutectic heats bismuth was added. Despite working at lower silicon levels (40 points lower) the bismuth was not able to prevent proeutectic flake graphite or Kish.

The base composition used for hypoeutectic heats was around 2.68 per cent C and 1.85 per cent Si. A standard addition of 0.04 per cent Te and 0.02 per cent B was made. Metallographic examination showed that heats not desulfurized contained lacy flake graphite. Upon desulfurizing, this lacy graphite disappeared. The other form of graphite noted was of a compact nature. This was of stubby to slightly spherodized shape. Heat M46 was the best structure produced.

Cerium Additions, Prior Desulfurization

Since cerium is a known desulfurizer, it was decided to add this element as a late plunging addition. In heat M52, an addition of 0.03 per cent Te and 0.68 per cent Ce was made. The microstructure of this specimen contained well formed compact graphite, as shown in Figs. 3 and 4. This was by far the best structure produced. The casting fracture was also distinctively different from past heats in that it contained many mottle specks which were fine, almost pin-point in size. This was described earlier, and is called compact graphite mottle-white fracture, CW.

Additional heats were made using cerium additives but no tellurium. Heats M59, M60 and M63 show the effect of varying amounts of cerium additions. The change from gray fracture to compact mottle-white occurred at 0.25 to 0.30 per cent Ce added. In all cases the compact graphite was well formed but not as good as M52 where Te was used as well as Ce for addition. All heats where Ce alone was added showed remnants of flake graphite and had some stubby, in addition to the better formed compact graphite. Higher Ce additions produce better compact graphite at percentages above the minimum needed to produce a CW fracture.

Cerium Additions, No Prior Desulfurization

Further work with cerium was continued. However, in this series of heats no desulfurizing was done other than by the cerium addition. Heats M73 through M83 show the effects of different per cent cerium additions at different silicon levels. The two silicon levels selected for the base composition were 1.55 and 2.25 per cent Si along with 2.50 per cent C. At each of these silicon levels a series of cerium additions (0.2, 0.4, 0.6 and 0.8 per cent) was made.

At any of these silicon levels the percentage addition required to change from flake graphite iron fractures to a compact graphite or a white iron structure was between 0.3 and 0.4 per cent Ce. Below 0.3 per cent Ce the desulfurizing and carbide stabilizing effect of the cerium was not sufficient to suppress flake graphite. Above 0.4 per cent Ce the flakes were suppressed and a CW structure resulted. The number of compact graphite particles formed was not appreciably affected by silicon percentage, but the size (and extent of graphitization) was greater at the higher silicon percentage.

Mischmetal Additions

At this point it was decided to use mischmetal as a source of cerium. A commercial grade of mischmetal of analysis 47 per cent Ce and 95 per cent total rare earths was secured. Heats M84 and M85 compared the effect of mischmetal and comparable amounts of cerium. From these heats it was concluded that comparable amounts of cerium and mischmetal are equivalent in their effect on the microstructure of cast iron for the grade of mischmetal tested.

Another series of heats was run to determine the effect of the temperature of addition of mischmetal. Heat M86 had mischmetal added at 3000 F (1649 C) and heat M87 had it added at 2900 F (1593 C). Neither of these microstructures showed significant change over that when cerium was added at the standard temperature of 2750 F (1510 C).

In this latter work it was noticed that a rather sharp break existed between the formation of flake graphite and a white or CW structure as the cerium addition was increased. This break was narrowed down to about 0.4 per cent cerium or mischmetal in undesulfurized iron. Slightly below this level flake graphite existed, but also with abundant compact graphite. A mischmetal addition of slightly over 0.4 per cent eliminated these flakes, but also removed much of the desirable compact graphite.

Mischmetal Plus Tellurium Additions

Up to this point the best microstructure had been achieved with a combined cerium and tellurium addition. To determine what effect tellurium had and also to determine an optimum addition, a series of heats was run (M91-M99). In this series the base com-

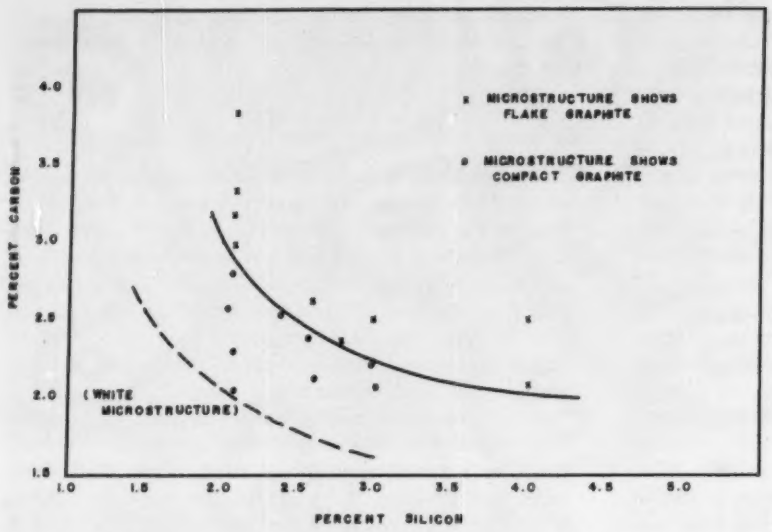


Fig. 5 — Composition range of compact graphite structures in as-cast irons as a function of per cent silicon and per cent carbon. A standard addition of 0.7 per cent mischmetal and 0.1 per cent Te was used.

TABLE 3 — BASE COMPOSITION EFFECT ON GRAPHITE STRUCTURE

Heat No.	Analysis, % C	Si	C.E.	Fracture	Nodule No./mm²	Structure
M 114	2.58	2.05	3.26	CW	458	SC
M 115	2.80	2.09	3.50	CW	342	SC
M 116	2.99	2.08	3.68	CW-G	225	F, SC
M 117	3.19	2.08	3.88	G		F, SC
M 118	3.44	2.08	4.13	G		F, SC
M 120	3.84	2.08	4.53	G		F, SC
M 121	2.30	2.08	2.99	CW	558	SC
M 122	2.08	2.08	2.77	CW	440	SC
M 123	2.56	2.40	3.36	CW		SC
M 124	2.38	2.57	3.24	CW	654	SC
M 127	2.34	2.77	3.26	CW	700	SC, S, F
M 128	2.50	4.00	3.83	CW-G		SC, F
M 129	2.08	3.00	3.08	CW-W	108	SC
M 130	2.08	4.00	3.40	CW-G		SC, F
M 131	2.13	2.60	3.00	CW-W		SC
M 132	2.25	3.00	3.25	CW	543	SC
M 133	2.63	2.60	3.50	CW-G		SC, F
M 134	2.50	3.00	3.50	CW-G		F, SC

CW — Compact graphite mottle-white fracture.
W — White fracture.
G — Gray fracture.
F — Flake graphite.
S — Spheroidal graphite.
SC — Stubby or nonspheroidal graphite.

position was 2.50 per cent C and 2.25 per cent Si. At different levels of mischmetal addition (0.3, 0.5, 0.7 per cent) varying amounts of tellurium (0.01, 0.05, 0.1 per cent) were added.

It was found that with 0.3 per cent mischmetal addition 0.01 and 0.05 per cent tellurium additions were not sufficient to suppress flake graphite while 0.1 per cent Te was. M92 (0.05 per cent Te) showed the best compact graphite including some spheroids. A few surprising observations were: 1) M91 (0.01 per cent Te) and M92 showed a chilled rim 2) M92 showed heavier flakes than M91 3) M92 and M93 had quite a few sulfides present. The sulfides were not expected because of the desulfurizing effect of mischmetal, and are not present if tellurium is not used or the per cent added is low.

With the 0.5 per cent mischmetal addition all levels of tellurium addition suppressed flake graphite. M94 (0.01 per cent Te) displayed the best compact graphite. Again, it was surprisingly noted that many sulfide inclusions appeared in the higher tellurium addition heats, i.e., M95 (0.05 per cent Te) and M96 (0.1 per cent Te). Few if any spheroids were observed.

All the 0.7 per cent mischmetal heats, M97 (0.01 per cent Te), M98 (0.05 per cent Te) and M99 (0.1 per cent Te) produced the best microstructures up to this time. M99 had the best examples of compact graphite while M98 was second. Again, sulfides were noted in M98 and to lesser extents in M97 and M99.

Another series of heats was run at 1.50 to 1.60 per cent Si and 2.35 to 2.50 per cent C, in which the size of tellurium and mischmetal addition was varied. Results were similar to those of the higher silicon level. 0.7 per cent mischmetal and 0.1 per cent Te were found to give the best compact graphite structure. One interesting fact noted in this low silicon range was that a good compact graphite was observed at 2.40 per cent and 1.60 per cent Si, and an addition of 0.7 per cent mishmetal and 0.1 per cent Te. The graphite nodules were well formed, and some appeared to be good examples of spheroids. However, these nodules were small.

Carbon and Silicon Effect

To determine the influence of base composition on graphite structure, heats were made with a standard addition of 0.7 per cent mischmetal and 0.1 per cent Te. These heats are listed in Table 3, and plotted in Fig. 5. In cases where it was possible to make nodule counts these are listed. However, such counts should be considered with reservations as the error involved in this low nodule counting area is considerable.

In these heats the variables were the per cent carbon and the per cent silicon and the carbon equiva-

lent. In heats M112, M114, M115, M116, M117, M118, M121 and M122 the per cent silicon was held constant at about 2.08 per cent, while the per cent carbon was varied from 2.08 to 3.84 per cent. This gave a carbon equivalent (C.E.) range from 2.77 to 4.53. A result of this series was that the nodule number increased to a maximum as the per cent carbon was increased from 2.08 to 2.30 per cent. Increasing the per cent carbon above this point resulted in lower nodule counts.

The microstructures showed less compact graphite and a decrease in the quality of the graphite as the per cent carbon was raised. In a reciprocal manner the amount of flake graphite increased. These developments proceded in a progressive manner up to a C.E. of 4.3 or the eutectic composition. A heat M112 of hypereutectic C.E. showed flakes and compact graphite. It was not possible to take a nodule count, but it did appear there were slightly more nodules in this heat than in M118, a comparable heat just below the eutectic C.E. of 4.3.

In another series of heats both the per cent silicon and the per cent carbon were varied at a constant C.E. The range for C.E. was 3.00 to 3.83. Heats covered were M123, M124 and M127 through M134. It was noted that in comparison to heat M114, heats M124, M127 and M132 showed that at a particular C.E. a higher proportion of silicon resulted in an increased nodule number. Nodule counts made for M124, M127 and M132 showed that the nodule number reaches a maximum and then decreases as the per cent silicon is increased at a constant C.E.

Again, caution should be observed because of the inherent error involved in making these counts at low nodule numbers. As C.E. was increased the graphite was observed to become less compact. To summarize, with additives of 0.70 per cent Ce and 0.10 per cent Te to undesulfurized iron, the range of 2.35 to 2.50 per cent C and 1.60-2.25 per cent Si produced the maximum number and size of compact graphite nodules, as-cast.

SUMMARY

Tellurium has a major effect of suppressing flake graphite nucleation in the normal eutectic temperature range. It has a minor effect of permitting a limited nucleation and growth of compact graphite. These effects are dependent on the carbon and silicon content and amount of tellurium addition. At carbon and silicon percentages just over the mottle limit for a 0.01 per cent Te addition, the graphite is lacy and the fracture mottled. Raising the Te addition to 0.04 per cent permits compact graphite to predominate. The fracture then changes from mottled to a compact graphite-white fracture.

Raising the carbon and silicon percentages causes a return of the lacy graphite, and requires an increase in Te addition to eliminate this flake graphite. There appears therefore to be a limiting number of compact graphite nodule that can be developed using Te alone. The maximum number of compact graphite nodules is 150/mm^3 developed in heat M11. Tellurium was effective in both hypoeutectic and hypereutectic compositions.

Bismuth appeared incapable of preventing flake graphite nucleation in a mottled fracture in the hypereutectic composition range. No work was done with hypoeutectic heats.

Cerium was able to prevent flake graphite from forming at 1.50 per cent to 2.25 per cent Si and 2.50 per cent C. It also served to nucleate compact graphite and spheroids. The addition required depended on the percentage sulfur in the iron. In undesulfurized iron at 0.07 per cent S, an addition of 0.40 per cent Ce is the minimum required. The fracture changes from gray to compact mottle-white fracture with no transition to the conventional mottle fracture. These observations also apply to the use of mischmetal to replace cerium.

When Te and cerium are combined, a lower percentage of cerium can be used to obtain compact graphite. For example heat M93 had 0.30 per cent cerium added and would have a gray fracture, but by the addition 0.10 per cent Te was caused to have a compact mottle-white fracture.

Based on the additions and base compositions studied, a combination of cerium or mischmetal and tellurium has produced the best as-cast compact graphite. This is exemplified by heats M52, M99 and M139, and Figs. 3 and 4. Base composition has considerable effect on as-cast compact graphite. In the range of 2.35 to 2.50 per cent C and 1.60 to 2.25 per cent Si, the maximum amount of compact graphite was noted.

It should be recognized that this is a progress report of a limited amount of research aimed at producing compact graphite in cast irons of a chemical composition in the malleable iron range. There is no intention of advocating a certain addition or process, nor of implying that this can be accomplished on commercial castings. However, it is hoped that research will be continued in this direction.

ACKNOWLEDGMENT

The authors wish to acknowledge the following for their assistance and support on this project:

The AFS Training & Research Institute for their sponsorship of this project, and members of the AFS Malleable Division Research Committee for their efforts in guiding this project: C. F. Joseph, *Chairman,* W. D. McMillan, *Vice Chairman,* W. K. Bock, H. Bornstein, J. H. Lansing, G. B. Mannweiler, R. V. Osborne, R. P. Schauss, R. Schneidewind, E. J. Stockum, P. F. Ulmer and E. Welander.

P. C. Rosenthal, *Chairman,* Dept. of Mining and Metallurgy and W. R. Marshall, *Assoc. Director,* Engineering Experiment Station, for their administrative assistance.

REFERENCES

1. C. R. Loper, Jr. and R. W. Heine, "Heavy White Iron Section Melt Additions on Mottling Tendency," AFS TRANSACTIONS, *vol. 68* (1960).
2. C. R. Loper, Jr. and R. W. Heine, "Mottling in Heavy Section White Iron Castings," AFS TRANSACTIONS, *vol. 67* (1959).

COST CONTROL THROUGH PROCESS QUALITY CONTROL

by C. E. Haney

ABSTRACT

The author's company has established a process quality control program for cost reduction and quality improvement. This article discusses the need for process control, the approach to identification of significant process cost and quality factors, application of process controls and organization of the new department.

INTRODUCTION

It is tough to make a profit in the steel foundry business in the current competitive market. Prices are low, material and labor costs are continually rising and production quality requirements are getting more rigid all the time. Under these conditions, management looks one remedy squarely in the eye — cost reduction.

There are, of course, a number of ways to reduce costs. Some common examples are work simplification programs, intelligent and alert purchasing practices, up-to-date plant layouts, a streamlined organization and other efforts designed to promote efficiency. Good management must recognize the importance of all such programs in order to insure growth in spite of adverse current conditions.

A newer approach to cost reduction which can be extremely important, particularly in the jobbing foundry where true repetition is rare, is process quality control.

Quality control usually implies inspection and control of an end product or component. Process quality control provides inspection and control of processes, and considers the end product, the individual casting, as it is affected by processes in its manufacture. Processes which are capable of producing the product to a satisfactory quality level must be chosen and kept in control.

The following discussion outlines the author's company's efforts in the field of control of process. The idea is not original — other foundries have set up parts of the program in the past. The methods of implementing and integrating process quality control in this operation may present some new twists for consideration.

C. E. HANEY is Vice-Pres. and Works Mgr., ESCO Corp., Portland, Ore.

NEED FOR PROCESS QUALITY CONTROL

The Trial Casting Problem

An illustration of the need for control of process is brought out by experiences with trial castings. When a customer's drawing arrives at the plant and a pattern is made, the first step, as in most foundries, is to make a trial before embarking on the production run. The trial is fully evaluated to be sure that it meets the customer's specification before releasing the pattern for production. A fairly common incident has been production of a suitable trial casting which passes all evaluation resulting in release of the pattern for production, and subsequent production of a group of castings which must be scrapped or heavily repaired before shipment.

A recent specific example was a group of washer castings for a missile launching installation. These were low alloy weighing about 100 lb, and had neck-down cores between the riser and the casting. The trials were excellent, there was no evidence of any defect at the riser contact or under the neck-down core and the castings passed x-ray and magnetic particle specifications without repair. The pattern was released for production, and the first 40 castings arrived in the cleaning room with serious sagging difficulties in the neck-down core.

The resulting depression required weld buildup and grinding and increased the cost of production. A few degrees increase in pouring temperature had caused the defect, and correction of this detail of process allowed further production without trouble. This example illustrates the way controlled process could have reduced costs by providing consistant quality.

Inconsistent Scrap Rates

From time to time high production items of low scrap history suddenly spring forth as scrap problems due to lack of process quality control. For example, a small casting which was made on a production

basis for years with well below one per cent scrap average suddenly turned up as a 13 per cent scrap item. The reason, broken cores; the remedy, correction of a defective core setting process. This resulted in the casting, which triggered the investigation, dropping back to its usual scrap rate. More important, scrap rates on other jobs, which were being adversely affected by the faulty process, were improved.

Inconsistent Repair Requirements

In spite of a lot of experience making certain production castings, wide variations in cleaning room repair time required to prepare the casting for shipment were found. One of the best examples was a large stainless casting which had cleaning and repair times as low as 48 hr, and as high as 250 hr, within a group of about 50 castings. The correction of the condition causing this wide variation was modification of the gating system. Turbulent metal delivery had resulted in inconsistent surface on the casting requiring much grinding and chipping.

By the time full process quality control treatment had been applied, the average time was reduced from 118 hr on the first two-thirds of the order to 55 hr on the final third. In addition, the customer has reported a 60 per cent improvement in casting quality as indicated by dye penetrant examination following final machining. Movies were used to investigate this problem, and changes made after studying the pictures.

It is recognized that cost reductions of this magnitude are not usually possible; this particular casting required nearly perfect x-ray and dye penetrant inspection and an excellent surface. However, lesser but still significant cost reductions are possible on almost any type of casting.

IDENTIFICATION OF SIGNIFICANT PROCESS COST AND QUALITY FACTORS

"Pilot Heat" System

As a result of observing the difficulty of reproducing results, much attention was given to the quality control program. Quality control principles were already being applied to the obvious cost and quality factors, and an extensive casting inspection program was in operation. Some of the quality control efforts were already directed toward process—sampling of raw materials, daily sand testing, melt analysis using a direct reading spectrograph and control of pouring temperature with an immersion thermocouple.

In addition, many practices had been established and adhered to which apparently affected consistency of product—careful control of charge materials, purchase of refractories from reputable suppliers, development of standard ladle preparation techniques, mold handling and drying practices, sand purchasing and process sample testing, and so on.

In addition, the laboratory provides all types of tests for verifying the end product quality, and the inspection force is equipped from *A* to *Z* for discovering flaws, including a 24 million volt betatron. As a matter of fact, from time to time it has been facetiously suggested by the company that the biggest product consistency problem is being so good at finding out what is wrong with the castings. If the castings could be given the quick once over of 15 years ago, the company would go merrily on its way, confident of excellent continuing quality.

Inconsistencies in scrap rate were noticed, and repair requirements continued in spite of application of the quality controls. The obvious conclusion that at least some of the factors which had an effect on quality were not being controlled, and the company set about the job of identifying these factors. At this point the "pilot heat" procedure was originated. This consisted of assigning two top men, the Asst. Works Mgr. and the Manager of the Metallurgical Department, to the job of observing every detail of heats scheduling castings showing wide quality variations.

Their approach was to gather all the information they could on the details of processes in practice. Nothing was excluded as being too unimportant for consideration as a possible factor. Samples of the type of information gathered are shown in Figs. 1 to 4.

An example of the type of information collected and considered during this pilot heat period of the development of process quality control was handling of backing sand at one molding station. One molder would shovel spilled sand from the floor into the mold as backing sand without adding any water to it. The molder on the next machine liked to sprinkle down the floor around his machine, and when he shoveled this sand into the mold as backing it was considerably wetter. True, it was never established definitely that this had an effect on quality, but it is a good illustration of the type of detail which is normally completely unnoticed that was considered as a possible factor in process quality control during the pilot heat period.

During this pilot heat development period, it was noticed that casting quality jumped up when a heat was labeled a "pilot heat"; no bad castings were produced during these heats. Since this was not limited to one pattern or another, it was concluded that the effect of added attention on process was responsible.

Brainstorming the Problem

When the pilot heat procedure was well established, a brainstorming session was arranged. Here an attempt was made to get every idea supervisors and pilot heat observers could suggest on possible quality factors in the processes. This was approached by taking the top ten scrap causes and discussing the possible reasons for their occurrence. A sample idea list which resulted is shown in Fig. 5.

Notice that a number of ideas were listed which have limited bearing on the scrap cause. It is felt that the atmosphere of free discussion with no idea being rejected was most beneficial.

Process Quality Control Check Lists

The ideas gathered at the brainstorming session were discussed and either retained or discarded, leading into the development of the process quality control manual. A page from this manual is shown in Fig. 6.

PILOT HEAT

MOLD DATA

HEAT NO. _____ Date _____

Time molded _____ By _____

Mold hardness _____ C _____ D

Time wash applied _____ Lbs. wash _____ Method _____

Wash viscosity _____

Time mold completed _____ Time oven started _____

_____ hrs. to _____ , _____ hrs. at _____

Time out of oven _____ Time cores in mold _____

Time heater on _____ Time heater off _____

Time closed _____ Core temperature _____

Temperature measured where _____

Temperature measured how _____

Time heat tapped _____ Time mold poured _____

Pour time, seconds _____

Ladling detail remarks _____

_____

_____

Pouring temperature _____ How measured _____

Fig. 1 — Sample of mold data gathered. See also Fig. 2.

PILOT HEATS

MOLD DATA (2)

SAND DATA

Facing Sand

		Permeability		Compression				
Type	Moisture	Green	Dry	Green	Dry	Flowability	Deformation	Density

Backing Sand

		Permeability		Compression				
Type	Moisture	Green	Dry	Green	Dry	Flowability	Deformation	Density

REMARKS

Molding _____

_____

_____

Mold washing _____

_____

_____

Mold drying _____

_____

Mold handling _____

_____

Fig. 2 — Sample of mold data gathered, in addition to Fig. 1.

As is evident, this is an edited list of the ideas from the brainstorming session in the form of a checklist for the process quality control inspector to use in performing his job. This manual is used by the process inspector in investigation of deficiencies, either by location or by job. Notice that "process" and "pattern" factors are included in this checklist. As is immediately obvious, a defect under investigation may be caused by a process deficiency (misrun, for example, by low pouring temperature) or a problem with an individual pattern (misrun, for example, by a poorly designed gate).

APPLICATION OF PROCESS CONTROLS

Casting Planning Stage

Choosing processes capable of producing the casting required is the responsibility of the job methods

PILOT HEAT

CORE DATA

Heat No. _____ & _____ Date _____

Core Hardness	Hardness Green	Scratch
Core Number _____	___C___D	___C___D
Core Number _____	___C___D	___C___D

Core Maker _____ Core Sand _____

Type & Batch	Moisture Green	Moisture Dry	Permeability	Flowability	Deformation	Density

Time core completed _____ Time start dry _____

Time first coat of wash _____ Method _____

_____ hours to _____ _____ hours at ___

Time out of oven _____ Time drag core washed ____

Time pasted _____ Time cope core washed ____

Time in oven for wash dry _____ _____ min. at ____

Date wash batch prepared _____ Viscosity _____

Wash application method _____

Core temperature when washed _____ Cope _____ Drag _____

How measured? _____

Fig. 3 — Sample of core data gathered. See also Fig. 4.

PILOT HEATS

CORE DATA (2)

Wash applied by _____ Core pasted by _____

Core to hot room _____ (Date) _____ (time)

Core out of hot room _____ (Date) _____ (time)

Core in mold _____ (time)

REMARKS

Core making _____

_____

_____

Core washing _____

_____

_____

Core handling _____

_____

_____

_____

Fig. 4 — Sample of core data gathered, in addition to Fig. 3.

group. This group functions on the staff of the foundry superintendent, and its recommendations on risering, gating, pattern equipment and special foundry techniques must be accepted by the superintendent or one of his assistants, and the molding foreman before the trial is rammed up. Permanent records are initiated on each new job, including detailed rigging sketches. When trial castings have been made and evaluated, the results are added to the information in the files. Any changes required are noted, and subsequent trial castings results are recorded until a satisfactory part is produced and the pattern is released for production.

The purpose of making such a point of recording every step of the trial casting work is twofold. First, it is useful in troubleshooting should a problem develop at some later time. Second, successful techniques used on one casting can later be applied to similar castings. The files are arranged by customer name, with cross references locating the casting folder by pattern number and casting description.

If, during this planning stage, the job under consideration appears likely to be particularly troublesome, or if it promises to be an important production item, it is designated a *P* order; a "Process Quality Control" order. This prefix on the order number says "look out for this: it is tough and important," and alerts everyone to give special care to the job.

If some specific problem is foreseen, special precautions will be taken as appropriate. Examples are special handling instructions, trial evaluation beyond the specification, sending the trial to the customer for approval or any number of similar special steps designed to ensure a satisfactory quality level.

If the problem cannot be predicted before the trial is made, but special control is necessary, the process quality control inspector will be asked to pilot the heat in which the trial is poured.

The job methods system of casting planning has contributed materially to scrap reduction and improved casting quality with lowered cleaning and repair costs. It is tied in directly with the process quality control program; the files of both are consolidated where individual jobs are reported on, and process quality control inspection is often called upon for investigation of a pattern problem by the Job Methods Department.

Process Controls

When processes have demonstrated their capacity to produce a satisfactory trial casting, responsibility for control of the processes is assumed by the supervisory group. Process quality control is applied as staff assistance where required.

The processes included in the current program are molding, coremaking and pouring. Conspicuous by their absence are melting, sand preparation, cleaning and heat treating. Melting is controlled by the metallurgical laboratory staff, and statistical quality control and inspection of the process, as well as record keeping, are the responsibility of this group.

Sand preparation is controlled by the sand lab, which is a part of job methods. Sand sampling and charting of properties found in the samples are long

MISRUN

PROCESS

A. Wrong pouring temperature (cold metal or too hot).
B. Heavy Oxide (Hi alloy-Mn).
C. Improper pouring technique.
   1. Ladle too high.
   2. Slow pouring.
   3. Interrupted pouring.
   4. Mold improperly weighted.
   5. Number of stops.
D. Lip designed wrong. Wide stream.
E. Sticky stopper.
F. Stopper size. Pouring too slow.
G. Ladle too full.
H. Cold teapot spout.
I. Poor shank fit.
J. Unskilled steady man.
K. Mold media.
L. Mold temperature.
M. Location of mold on rack.
N. Mold position. Uphill pouring.
O. Floor preparation. Slow heat pour-off.
P. End core size and cup size. (c)
Q. Metal in ladle as related to size castings. (Carrying metal back and forth in pouring ladle.)
R. Spinning speed.

PATTERN

A. Gate too small.
B. Improper ingate contact.
C. Improper flows.
D. Rigging (Williams vs. Open Riser)
E. Gate location.
F. Chilling - location, size.
G. Size - shape pouring cup.
H. Pounds castings per box.
I. Casting position.
J. Casting location as related to gate.
K. Casting design - Metal section.
L. Core venting.
M. Low Cope - insufficient head.

Fig. 5 — Sample idea list resulting from brainstorming session.

standing procedures, as are periodic inspections of sand handling and mixing equipment. A newer tool which permits "phantom" process inspection is the use of a recording wattmeter on the sand mill to observe and record the mixing procedure.

MISRUN CHECKLIST

Inspector:_____ Date:_____ Location:_____
Pattern or Patterns Inspected_____ Heat No._____
Process
Pouring Temperature_____
Pouring Technique Comments_____
_____
Ladle Height O. K.?_____ Stops per Ladle_____
Pouring Time_____
Ladle Comments_____
_____
Spout O. K._____ Filled Properly_____
Stopper O. K._____
Mold Placement, Position_____
Pattern
Gating Comments_____
_____
Size_____ Contact Size_____
Location_____ Sprue size & type_____
Cope Height_____
Rigging Comments_____
_____
Riser Placement_____
Chill Placement_____
Recommendations
_____

Fig. 6 — Sample page from process quality control manual. Compare with checklist in Fig. 5.

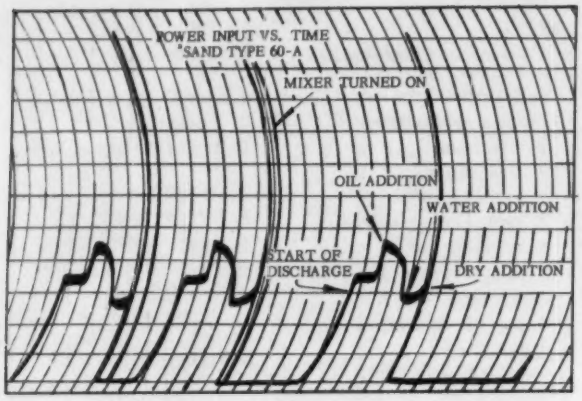


Fig. 7 — Tape on which wattmeter has plotted power input vs. time for batches of the same type of sand.

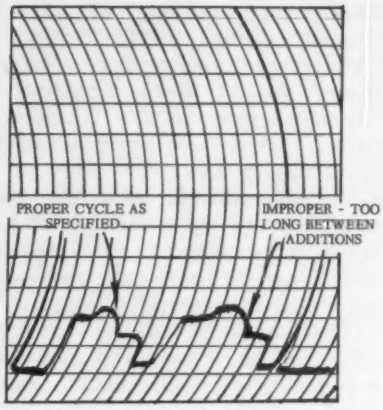


Fig. 8 — Wattmeter tape for power input vs. time for sand type (61D) showing proper and improper mixing of batches of sand.

Figure 7 shows a tape on which this device has plotted power input versus time for a group of batches of the same type of sand. These sand batches have been mixed properly and consistently. Notice the similarity in curve shape. The chart reads from right to left and each vertical graph line represents 2 min in time. The curve fluctuations are marked to show the operation details.

In Fig. 8, curves showing improper and proper mixing of batches of another type of sand are shown. This particular cycle calls for mixing 3 min after both water and oil additions. In the first cycle, 4 min went by before the subsequent addition. The second curve describes a properly mixed bath. The sand laboratory has excellent control of sand preparation processes, and the application of the new process quality control program to other, more fertile fields was considered more important.

A number of controls have long been applied to heat treating processes. Periodic oven surveys and oven temperature-time charts are used, as is inspection of the process by members of the metallurgical laboratory and operating supervision.

The cleaning process in all of its complexity is not included in the current process quality control program. While it is true that cleaning processes greatly influence the final quality of the product, the inherent casting quality as it is shaken out is a much greater factor in final cost, and thus efforts have been concentrated on processes which can improve the quality of the casting as it arrives in the cleaning room.

The areas of concentration; molding, coremaking and pouring, are handled in one of three ways by the process quality control inspector—by spot checks, trouble shooting and pilot heat procedures.

Spot Checks

As an example, during a typical spot check of a molding location the inspector shows up unannounced and looks over the entire process. The pattern is inspected for general condition and suitability, as are all other pieces of equipment in use. Flasks (watch those pins and bushings—go, no-go gage them), jackets for snaps (clean and square), pattern plates (how is the match? section a mold), core fit (who knocked the corner off that print?), pattern wear (check the castings for dimensions if you are suspicious), squeeze pressure (how is mold hardness?) and so on down the list of equipment in use.

The inspector then goes over the process as affected by the molder. Proper facing (check mold hardness, facing depth, placement of special sands in fillets), ramming OK (watch for ram-off in the sectioned mold), gates cut and matched properly (uniform coat on entire mold), mold closing (cleanliness pays) and on through his checklist of molding processes.

The inspector's observations are reported to the superintendent who takes whatever corrective action is required through the foreman in charge of the molding area.

Trouble Shooting

If the scrap report shows that one particular pattern is giving trouble, or if cleaning room supervision reports an excessive repair or processing problem, the process quality control inspector may be called upon for determination of the cause of the defective castings. For example, Fig. 9 shows an excerpt from a scrap report which indicates that pattern T-196 has recently become a problem from the standpoint of misrun.

This report is made up by the tabulator from punched cards; the illustration is in different form because of size restrictions, but the column headings are self-explanatory and are as they appear on the report. The scrap versus production figures are checked against current target scrap level for this defect, shown in Fig. 10. These targets were arbitrarily chosen for 1960 based on desired improvements on losses for 1959. One more criterion is used which is completely arbitrary; this is the $100 minimum loss figure.

If less than $100 has been lost in scrap on an item, it is not pursued until the higher loss items have been worked on. This is done to avoid emphasis on low dollar producing items and low production jobs. It is easy to understand that higher percentage losses can be expected during early stages of production;

Location	Pattern Number	Cause	Current Month # Prod	Current Month # Scrap	Current Month $ Prod	Current Month $ Scrap	Year-to-Date # Prod	Year-to-Date # Scrap	Year-to-Date $ Prod	Year-to-Date $ Scrap	% of Scrap Year to Date	% of Scrap Current
2	T196		50		1,171		326		8,845			
2	T196	2 (Slag Inclusion)						2		58		
2	T196	10 (Misrun)		8		238		8		238		
2	T196	13 (Crack)						1		22		
2	T196	40 (Deformed or broken)						1		28		
2	T196	57 (Low Physicals)						1		28		
2	T196	59 (Quench Cracks)						1		30		
2	T196		50	8	1,171	238	326	14	8,845	404	19.0	4.5

Fig. 9 — Excerpt from a scrap report which indicates that pattern T-196 has recently become a problem from the standpoint of misruns.

this $100 cutting line lets the job "settle down" after the trial stage before a lot of effort is devoted to correction of scrap difficulties.

Control Limits

Figure 11 shows the control limits which are used in deciding whether or not to work on a scrap problem exceeding the $100 minimum, relating its importance in the overall scrap loss to numbers produced. This chart has been adapted from one designed by Kenneth M. Smith in a series of recent articles on the "average job" quality control system. As you can see, for a given target scrap level, a higher loss is tolerated in low production items than in high production.

Figure 12 shows the flag card used to notify pattern storage that action is to be taken on this pattern the next time an order is entered. Notice that action course no. 4 has been circled by the scrap report evaluator. This means that the process quality control inspector will be asked to investigate this job. Several other alternates are provided which can be used for different problems; for example, if shrinkage were the problem, this flag would serve as a reminder for job methods to review the risering, and action alternative no. 2 would be circled on the card.

The flag card is returned to the job method files when the next order is entered, and is matched with the duplicate card which is placed in the file folder with any supporting information. When the process quality control inspector is called upon, such as he is in the sample misrun problem, he will attack the correction by the use of his checklist which has been developed for the defect. His observations and resulting changes are recorded in memo form and retained in the job methods file after corrections are complete.

Pilot Heat Procedures

Still another way the process control inspector functions is in the continuation of the pilot heat procedure. The approach to "piloting" a job has been covered in an earlier section of this discussion; it differs from spot checking and troubleshooting in that the problem to be corrected is usually nonspecific.

For example, there would be no need to pilot the sample pattern number T-196, which is a known misrun offender; a checklist has been developed for that purpose. If, however, on some other pattern the Cost Department reported wide fluctuations in cleaning costs from casting to casting, and further checking showed the defects requiring correction to be of numerous types, asking the process quality control inspector to run a pilot heat would be considered. He would then report his observations in much the same way as the original "piloters" did—no holds barred on ideas, and no detail too trivial for consideration.

Assuming the piloted heat produces satisfactory

	Defect No.	1959 % of Gross	Target 1960 (Percent based on Gross Production)
Misrun	10	.47	.23
Cracks	13	.32	.16
Slag Inclusion	2	.22	.11
Quench Cracks	59	.16	.08
Oxide Metal	36	.16	.08
Deformed or Broken	40	.16	.08
Pockmarks	26	.15	.07
Shrink	14	.13	.06
Runout	11	.12	.06
Shift	6	.12	.06
Core Broken	21	.09	.04
Poured Short	12	.08	.04
Core Scabs	56	.07	.03
Mold Scabs	55	.05	.02

Fig. 10 — Current scrap level control targets. These targets were arbitrarily chosen for 1960 based on desired improvement on losses for 1959.

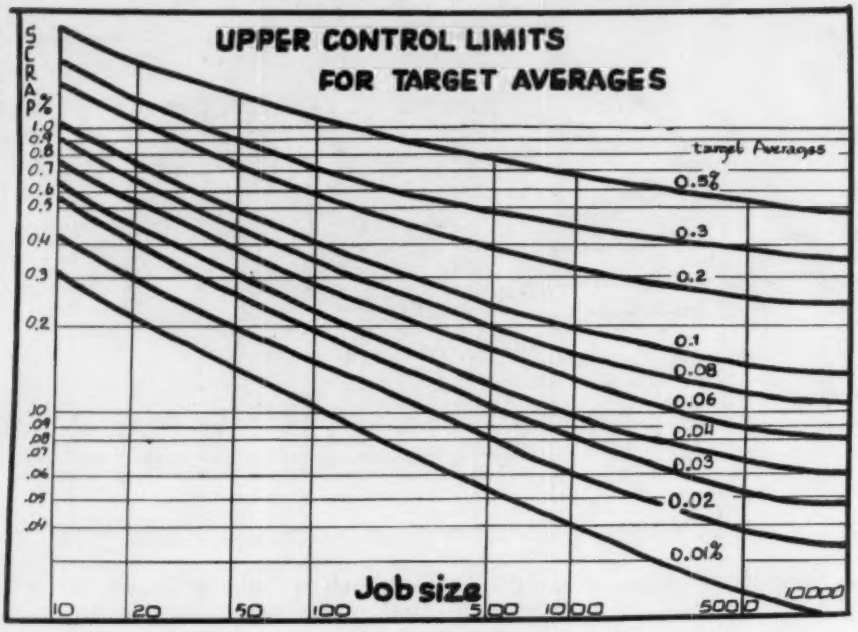


Fig. 11 — Control limits which are used in deciding whether or not to work on a scrap problem exceeding the $100 minimum, relating its importance in the overall scrap loss in numbers produced.

castings, as is often the case in practice, the process details observed are adopted as standard for making that particular casting. Special instructions are written for further production. These special instructions are the most important result of a pilot heat; a base for future comparison is established which allows detection of the subtle variations and degenerations which creep into most repetitive nonmechanized operations.

Because of the time required to run them, pilot heats are relatively rarely run, and are limited to high production, repetitive items.

Inspection Controls

The Casting Inspection Department is responsible for verifying final quality of the product, and also for assisting supervision by rejection of bad castings at various stages of production.

Final inspection to be sure the casting meets the specification is most certainly an important function, but the Casting Inspection Department provides a number of services which tie in closely with process quality control—reporting of scrap for tabulation by the Accounting Department, notification of defects needing correction on nonscrap castings, and most important, suggesting means for correction of defects observed. The chief casting inspector sits in on planning sessions in both lab and foundry, and his observations and ideas for corrective action are valuable. Because of the information which he has on defect recurrences, he can often sense trends which show the need for process control work. For example, assume that process quality control has corrected a recurring defect, and that production is satisfactory for a while, but the earlier problem begins to show up again. The inspector is in the best position to wave the red flag and call for renewed corrective effort, and can often suggest the solution through his experience in observing.

In the area of cost control and reduction, the Inspection Department has a vital function in processing castings in the cleaning room—the question of "Does it meet the specification in all respects and is it good enough?" is paramount. Equally important economically is the question "Has too much work been done and is it too good?"

In a shop which produces a wide variety of castings from a quality standpoint, making the casting to the required quality level is vital. It is easy to visualize a grinder who has spent half his day polishing liquid oxygen service valve bodies doing too much work on a ball mill liner. The Inspection Department helps to prevent this by watching for castings which are dressed up beyond necessity.

TO: PATTERN STORAGE When reordered send this sheet to Job Methods File
Main_____
Centrif._____
_____ (Date)

Please flag pattern No _____, last produced in _____ (Location)

This pattern shows _____ scrap of _____ produced for scrap cause # _____ (_____).

The next time we make this casting we will proceed as follows: (Check appropriate item)

1. Consult Planners
   a. Rigging
   b. Casting configuration
2. Job Methods review of rigging
3. Job Methods review of casting configuration
4. (4) Notify Process Control Inspector
5. Send note to Floor Foreman
6. Other

Fig. 12 — Flag card used to notify pattern storage that action is to be taken the next time an order is entered. The circled no. 4 means that the process quality control inspector will be asked to investigate the job.

ORGANIZATION AND RESULTS

Organization

Figure 13 shows the way the Process Quality Control Department fits into the foundry organization.

Notice that reporting is to the foundry superin-

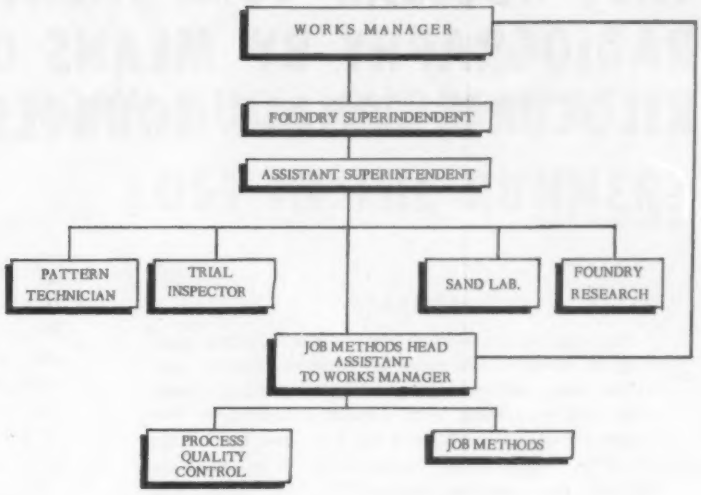


Fig. 13 — The way process quality control fits into the foundry organization.

tendent, through one of his assistants. This firmly establishes the service nature of the function—process quality control effort is thus applied where the superintendent feels it is most needed.

The line organization is separate from this chart. The assistant superintendent shown here also has line foremen reporting to him, but this chart shows only his staff capacity.

Centralization of planning and process control staff under this one assistant superintendent is also important. By this arrangement, he is in the position to coordinate the activities of the entire staff to produce the most effective service to line supervision.

Staffing

Development of procedures for process quality control was a joint effort on the part of the Works Manager, the Foundry Superintendent and the Job Methods Head.

Actual inspection has thus far been performed by one man, who is an experienced and respected foundryman. An injury left him with a disabled arm which incapacitated him for his former leadman's job. His long experience in various jobs throughout our plant, coupled with an especially alert and questioning mind, makes him an ideal process quality control inspector.

The experience of this individual has been an important factor in the apparent initial success of this new approach. He is respected by the men in the shop who know that he is capable of doing any job which he is inspecting. His performance so far indicates that future additional inspectors should be carefully chosen from shop personnel.

Results

It is difficult to estimate the part which process quality control has had in the general improvement of manufacturing costs which have been experienced in the last year. The program is new and small, and several other changes have been concurrent. Line supervisors have become more concerned with scrap losses, with increasing emphasis on their responsibility for control of process with staff assistance available as needed.

Figure 14 shows the recent downward trends in scrap losses and manhours per ton, which have both been influenced by this new program. These are the two yardsticks, other than profit, that are known to use in evaluating effectiveness of cost control through process quality control.

ACKNOWLEDGMENT

This paper has been prepared with the cooperation and assistance of Mr. William A. Meyer, Assistant to Vice-Pres. and Works Mgr. of ESCO Corp. Mr. Meyer is in charge of the job methods and process quality control work.

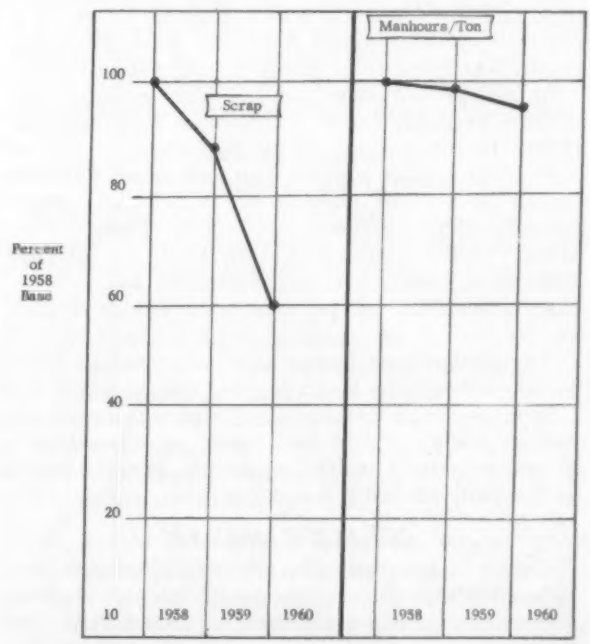


Fig. 14 — Recent downtrends in scrap losses and manhours per ton, which have been influenced by this program.

CAST NUCLEAR COMPONENTS RADIOGRAPHY BY MEANS OF KILOCURIE COBALT SOURCES

by Richard Lent

ABSTRACT

Kilocurie cobalt sources enable the author's company to meet requirements of stringent quality control on heavy section castings without resorting to high cost x-ray equipment with difficult maintenance. Exposure times of from 1.2 min for 2 in. steel to 175 min at 36 in. source to film distance for 10 in. steel are typical. This program meets MIL Spec 271A with qualification from the Bureau of Ships for the range of 1½ to 10 in. of steel.

HEAVY SECTION RADIOGRAPHY

Radiography of heavy sections is by no means a new field, as it had been accomplished originally by pioneers in the field using radium sources. The results obtained by this approach to radiography was a far cry from present day radiography requirements, whereby sensitiyities of 2 per cent or better are now routinely met.

With the advent of the betatron and linac, heavy section radiography moved forward to a more precise standard. Meanwhile radiography using isotopes had suffered, for to radiograph a heavy section by means of the isotope required a physically large source to accomplish the radiography in a reasonable time. The geometry conditions of such a large physical source in a radiographic setup was a limiting factor. If a physically smaller source had been used the radiography was defeated by excessive scatter conditions.

At the present time, due to high neutron flux reactors, available radioactive isotopes are greatly enriched. In the parlance of the field they are said to have a high specific activity. This now allows a greater output in a small physical size which fully meets radiography requirements of geometry. These sources allow heavy section radiographs to 12 in. of steel with better than 2 per cent sensitivity, and in some cases better than one per cent sensitivity in sections greater than 2 in.

The predominate isotope to be discussed in heavy section radiography is cobalt −60. The nature of this isotope lies in an emanation of a gamma ray of the average energy of 1.25 mev, which to all intents is mono-energetic. We might say that this behaves similar to a heavily filtered 2 mev x-ray beam.

COBALT CAMERAS

Cobalt cameras are now available capable of containing 3000 curies of high specific activity enabling a beam of radiation approximating 2700 R.H.M. The focal spot available is one cm. The work at the author's company's foundries is accomplished with this focal spot size. The camera is versatile in its mounting, allowing all of the necessary adjustments to accomplish the right direction of the beam to produce the needed radiograph.

The cobalt camera is remote controlled by means of a console incorporating automatic exposure timing features, and three separate safety controls to insure that the source is properly safed. These safety controls assure that the source will be returned to the safe position should unauthorized entry be made into the exposure area, or should there be any loss of control from the console.

At the company's foundries, radiography of stainless steel castings for nuclear valve parts is performed by 1000 curies of cobalt giving a beam of approximately 1100 R.H.M. Some typical exposure times with this cobalt source using sensitive film to a density of 2.0 at a 60 in. source to film distance are:

1) 2 in. steel – 1.2 min.
2) 5½-in. steel–8 min.
3) 7 in. steel – 22 min.
4) 10 in. steel – 175 min at a 36 in. source to film distance.

The radiography program meets MIL Spec 271A with qualification from the Bureau of Ships for the range of 1½ to 10 in. of steel.

CLASS ONE RADIOGRAPHY

Experience at the author's company has been an achievement of Class 1 radiography of steel sections above 3 in., due to the high output of the cobalt source. It might be noted that if the present source were replaced with the high specific activity cobalt now available exposure times could be cut by a factor of 2.5. The technique requires 0.010 in. lead screens front and back with 0.030 in. front filter and the cassette backed up by ½-in. of lead in cases where the scatter is great.

While the film interpretation is more difficult with the lessened contract of cobalt, this is more than offset by the wide latitude gained in the use of cobalt as a radiographic source. This wide latitude allows interpretation of wide variations in thickness, as is encountered in the typical foundry product without the loss of sensitivity in these varying thicknesses.

In summary, the findings at the author's company enable the company to state that kilocurie cobalt source material have definitely met the requirements of the stringent quality control on heavy section castings without resorting to a high cost x-ray installation whose maintenance about a foundry is difficult.

R. LENT is with Pacific-Southern Foundries, Inc., Long Beach, Calif.

HOW MUCH SUPERHEAT IS LOST IN THE RUNNER?

by J. W. Hlinka, V. Paschkis and F. S. Puhr

ABSTRACT

A runner can be thought of as a thick walled channel through which a hot liquid flows. There is a formula that allows estimation of, under certain conditions, how much heat is lost by the metal as it passes through the runner, and what the temperature of the metal will be as it exits. In addition, the formula discloses how the various runner design characteristics influence the loss. Providing all other design characteristics are held fixed, the loss in the runner depends on:

1. The length of the runner. Increasing the length of the runner by some factor will increase the temperature loss by the same factor.
2. The perimeter of the runner. Increasing the perimeter of the runner by some factor increases the temperature loss by the same factor (providing the flow rate stays the same).
3. The flow rate (lb/min of metal flowing in the runner). Increasing the flow rate by a factor decreases the temperature loss by the same factor.
4. The critical design characteristic. A most convenient form of the above items results if we multiply the length (item 1) by the perimeter (item 2) to obtain the surface area of the runner. Dividing the surface area by the flow rate (item 3) leads to a critical design characteristic of surface area to flow rate. This is the most important factor which governs the temperature loss for a given metal and mold material. Increasing the critical characteristic by a factor increases the temperature loss by the same factor.
5. Comparing two metals, the one having a specific heat larger than the other. The metal with the larger specific heat will have a smaller temperature loss. The specific heat is the most important thermal property of the metal.
6. The temperature loss depends on the square root of the product of conductivity, density and specific heat of the mold material.
7. Nearly the full effect of an increase in superheat is realized in the mold.
8. The temperature of the metal leaving the runner increases during the time the mold fills. In other words, the temperature loss decreases with time. More precisely, the temperature loss decreases inversely with the square root of time.
9. While it is highly probable that some freezing takes place along the walls of most runners, this factor is disregarded.

J. W. HLINKA is Sr. Rsch. Engr., V. PASCHKIS is Prof. in Mech. Engrg., Dir. and F. S. PUHR is Rsch. Engr., Heat and Mass Flow Analyzer Laboratory, Columbia University, New York.

INTRODUCTION

A large body of research in foundries has been devoted to solidification problems, including both experimental and mathematical studies. Generally, such work dealt only with the freezing in the mold cavity, and even the filling time of the cavity was usually disregarded. The present study deals with the temperature loss in runners, and should lead to a better understanding of the design requirements of runners, sprues, etc., in short, any opening through which hot metal is flowing.

In this study some considerations are presented which were made in anticipation of a more thorough examination, together with preliminary estimates, using a simple formula, that can be found in books on heat transfer[1] and here in the Appendix. This formula predicts the temperature loss (heat loss) in a runner and indicates which factors dominate the loss and in what way; therefore it has practical value.

FACTORS CONTROLLING TEMPERATURE LOSS

As usual in an estimate, refinements are dropped and only items which appear to be important are considered. Factors that affect the temperature loss in a runner are:

1. Kind of metal being poured.
2. Kind of mold material surrounding the runner.
3. Runner shape, perimeter and length.
4. Flow rate of the liquid metal.
5. Pouring temperature.
6. Mold temperature before pouring.
7. Time after the runner is filled.

Figure 1 is a schematic of a runner system. The numbers relate to the seven factors listed.

Regarding item 7, the runner is at first cold, and the superheat lost in the runner is large. Later on, when the runner walls are warmed, the superheat lost will be smaller. Therefore, the temperature of the metal leaving the runner increases with time. This

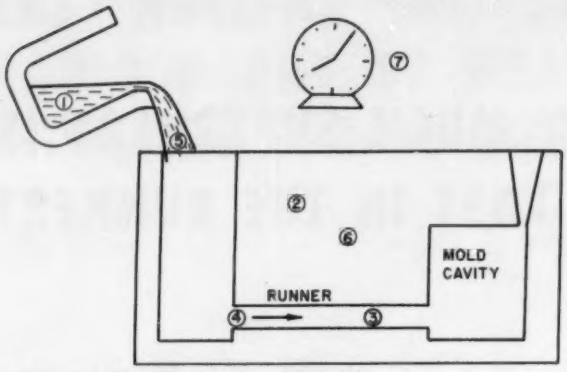


Fig. 1 — Simplified gate-mold system.

is important because to show the temperature of the metal entering the mold, the time this temperature exists must be shown. In this report, time is always measured from the start of filling and not the start of pouring, i.e., time zero, when the counting starts, is the time when the metal first leaves the runner and enters the mold cavity.

Of course, there are other factors which will affect the temperature loss, such as the skimming gate, which will influence not only the flow rate, but the kind of flow, the heat transfer coefficient developed at the interface between the metal and runner, the fact that the thermal properties of both runner and metal change with temperature, and, of greatest importance, the freezing and remelting which can take place. These and other factors were neglected in this preliminary study.

APPROXIMATIONS TO FIT FORMULA

A mathematical statement of the problem is given in the Appendix for those who prefer equations, but here the above list of items and the assumptions which were made are surveyed so that the formula can be applied to a runner.

Kind of metal being poured. The way the problem is stated in the Appendix, regarding how heat is transferred in the metal, the specific heat of the liquid metal is the only physical property which appears. Because of the turbulence in flowing metal, differences in the thermal conductivity of different metals are ignored. Freezing and remelting are disregarded, if any takes place, and thus the latent heat is also ignored. The density enters into the flow rate.

Kind of mold material surrounding the runner. It is assumed that the thermal properties of the runner material are not affected by changing temperatures, but rather stay constant during the filling time.

Runner shape, perimeter and length. The shape (i.e., trapezoidal, square, etc.) of the cross-section of the runner is disregarded, and only the product of the perimeter and the length is pertinent. This product, perimeter multiplied by length, is the surface area of the runner in contact with the liquid metal.

Flow rate of the liquid metal (lb/min). It is assumed that the metal flows through the runner at a constant flow rate. This is not true, because the pressure head in the sprue varies, at least when it is being filled. Also, a back pressure develops as the mold fills, which creates a varying velocity in the runner and thus a varying flow rate. However, an average flow rate is easily determined. Take the total weight of the metal that leaves the runner and divide this weight by the estimated filling time.

Pouring temperature. The temperature of the metal entering the runner is the same as the pouring temperature, and it does not vary during the filling time.

Mold temperature before pouring. The formula requires that, before pouring, the temperature of the mold material surrounding the runner is the same throughout. But this temperature need not be the shop temperature, since the formula applies to heated molds.

DETERMINING RUNNER TEMPERATURE LOSS

If the preceeding conditions are accepted, then the formula that may be applied to determine the temperature loss in a runner is:

$$\text{Temp. Loss} = \text{Constant} \times \frac{\text{Surface Area}}{\text{Flow Rate}} \times \frac{(\text{Pouring Temp.} - \text{Mold Temp.})}{\sqrt{\text{Time}}} \qquad (1)$$

It is convenient to express the temperature loss in percentage form. While usually the per cent temperature loss uses the pouring temperature as a reference or base point, the difference between the pouring temperature and the mold temperature will be used here. This is an improvement, because for metals having low melting temperatures the effect of the mold temperature cannot be ignored. Also, using the difference as a base makes it possible to determine the effect of heated molds. Thus:

$$\text{Per cent Temp. Loss} = \frac{\text{Temp. Loss}}{(\text{Pouring Temp.} - \text{Mold Temp.})} \times 100$$

$$= \text{Constant} \times \frac{\text{Surface Area}}{\text{Flow Rate}} \times \frac{100}{\sqrt{\text{Time}}} \qquad (2)$$

Where:

Temperature Loss is defined as the difference between the pouring temperature and the temperature of the metal leaving the runner (in degrees Fahr.).

The bracket term Pouring Temp. – Mold Temp. means the pouring temperature minus the mold temperature before pouring. For instance, if we pour at 1300 F into a mold at 100 F, the Pouring Temp. – Mold Temp. term in the formula would have a value of 1200 (use degrees Fahr. only).

The Per cent Temperature Loss, as defined by equation two, is the temperature loss divided by the Pouring Temp. – Mold Temp. and multiplied by 100. A per cent temperature loss in the runner of 5 per cent means 0.05 times the difference between pouring and mold temperatures. As an example, if the mold is at a shop temperature of 80 F,

and the pouring temperature is 1280 F, then the temperature loss in the runner would be 0.05 times 1200, or 60 F.

The Constant in the equations depends on the specific heat of the metal being poured and the runner material, and is given in Fig. 2 for sand runners only.

The Surface Area of the runner is the perimeter multiplied by the length (use in.).

The Flow Rate is the weight of the casting, including risers, etc., but not the gate assembly, divided by the estimated filling time (use lb for weight and min for time).

Time in the equation is defined as the time after filling begins (expressed in min).

This equation, discussed in detail in the Appendix, shows how the temperature loss of the liquid metal depends on the various factors. To what extent this simple equation will check with practice can be ascertained only when experimental data become available. The authors, however, have confidence that within practical limits, the results are useful.

There is a restriction which must be made when the equation is used. The equation is valid for per cent temperature losses not larger than 25 per cent and not smaller than 0.1 per cent. This is a wide range, since it is unlikely that 25 per cent of the pouring temperature would be lost in the runner, and losses of less than 0.1 per cent are not significant. Furthermore, the formula applies only when the temperature loss is less than the amount of superheat.

REMARKS

A conclusion which can be drawn from the formula is that when a given metal is being cast, the pouring temperature does not greatly affect the temperature loss in a runner. That this conclusion is correct can be reasoned from both heat transfer considerations and from mathematics. When two bodies, having different temperatures, are brought into direct contact, such as exists between the liquid metal and the mold, the amount of heat lost from the hot body to the cold body depends on the temperature difference between the bodies.

Therefore, if as an example, the pouring and mold temperatures are increased by 10 per cent, both the heat loss and the temperature loss in the runner will be increased by 10 per cent. Now, a 10 per cent increase in temperature may not seem like a large number, but 10 per cent of the pouring temperature when aluminum is being cast represents an additional superheat of about 120 F, which is quite a bit. Also, since all temperatures are increased by 10 per cent, the temperature loss will be increased by 10 per cent. Therefore in the example, the increase in the temperature loss would be 10 per cent of 120 F, or 12 F.

This means that of the 120 F additional superheat, 108 F finds its way into the mold cavity. For steel with a pouring temperature of 2800 F, a 10 per cent increase in superheat would be 280 F, of which 28 F would be an added loss in the runner, while 252 F will find their way into the mold cavity. The conclusion is that almost the entire increase in superheat finds its way into the mold cavity. The statement that temperature losses are proportional to the temperature difference between the metal and mold is not limited to the runner, but holds also for the gate assembly, except in regions where heat is lost by radiation and before freezing starts.

The equation arrives at the same conclusion, since it states that the temperature loss in the runner is directly proportional to the temperature difference between the pouring temperature and the mold temperature before pouring. Then the same argument holds. If this difference is increased by a certain percentage, then the temperature loss in the runner will at all times be higher by the same percentage, provided all the other factors remain unchanged.

In practice, the small effect of varying the superheat on the temperature loss would be unobservable, because the pouring temperatures could be varied

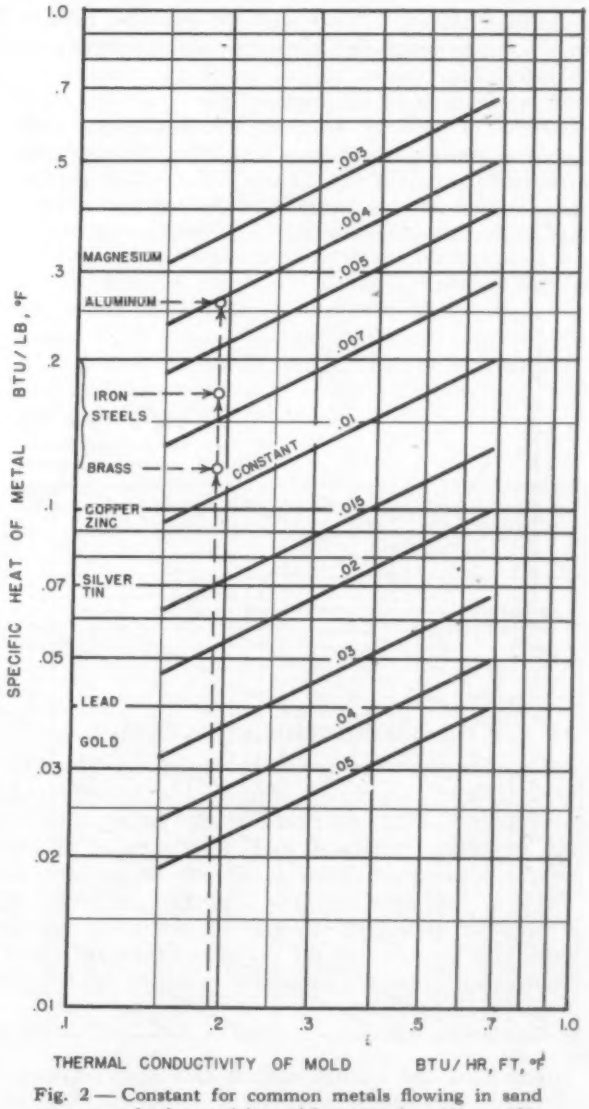


Fig. 2 — Constant for common metals flowing in sand runners to be inserted into either equation (1) or (2).

only within a fairly narrow range, unless special equipment were built.

Critical Ratio

It is quite interesting to note in the equation that for a given metal and mold material the per cent temperature loss, at a given time, depends only on the surface area of the runner divided by the flow rate. Since this combination seems to be the most important factor in runner design, the ratio of surface area to flow rate will hereafter be called the critical ratio.

The formula states that the per cent temperature loss has a one-to-one relationship with the critical ratio, which means that if the ratio is multiplied by a factor, the per cent temperature loss will change by the same factor. For example, if the ratio is doubled, the loss would be doubled. It is useful to know that the temperature loss is directly proportional to the surface area of the runner, and inversely proportional to the flow rate.

Another point of interest is the way the temperature loss changes with time. For a given metal and mold material and critical ratio the equation reduces to a number multiplied by one over the square root of time. This means that a graph of temperature loss versus time in all runners has a similar characteristic of a large temperature loss (large heat losses) at the start of filling, which rapidly decreases and tends to flatten out. Figure 3 shows this general characteristic. If this graph were plotted on logarithmic paper, the curve would be a straight line.

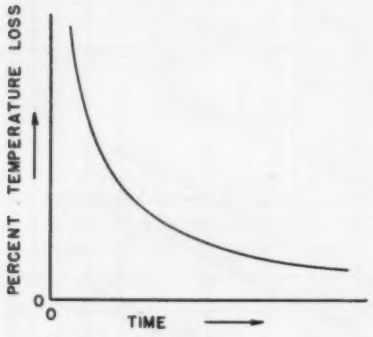


Fig. 3 — Per cent temperature loss for metals has a general shape, decreasing during the filling time.

GRAPHING THE EQUATION

Three metals were graphed — aluminum (Fig. 4), brass (Fig. 5) and steel (Fig. 6), flowing through sand runners. Each figure may be used for any alloy of the respective metal, as long as the value of the specific heat of the alloy is one of those listed in Table 2. If it does not have this value, a correction is applied, as will be discussed later. These figures show at a glance, how the per cent temperature loss changes with time for particular values of the critical ratio.

To use the graphs:

1. Calculate the runner surface area (the perimeter multiplied by the length).
2. Calculate the flow rate (weight of casting, including risers, divided by the estimated filling time).
3. Divide the surface area by the flow rate (this number is the critical ratio).
4. Refer to the figure corresponding to the metal being cast, and locate the line corresponding to the critical ratio (this line is the percentage temperature loss versus time for this runner).
5. To convert the percentage into degrees temperature loss, multiply the per cent temperature loss by the difference between the pouring temperature and the mold temperature, and divide by 100.

An example using aluminum (Fig. 4) is: Take a runner having a perimeter of 4 in. and a length of 10 in. The surface area is then 4 times 10, or 40 sq. in. The weight of the casting, including risers, is 40 lb, and the expected filling time is 4 min. This results in an average flow rate of 10 lb/min. Then 40 sq in. divided by 10 lb/min yields a critical ratio of 4. Refer to Fig. 4 for aluminum flowing through a sand runner. The dashed line shows the per cent temperature loss during the time of filling.

If in this example, the pouring temperature is 1400 F and the mold temperature before pouring is 100 F, the percentage temperature loss is multiplied by 1300 and divided by 100 to obtain the temperature loss in degrees Fahr. The factor 100 is used to reduce the percentage to a fraction. These results are shown in Table 1 for several values of time as taken from Fig. 4.

TABLE 1

Time, min	Temp. Loss, %	Temp. Loss, F,
0.1	5.0	65
0.2	3.6	47
0.5	2.3	30
1.0	1.6	21
2.0	1.2	16
4.0	0.8	10

In Figs. 4, 5 and 6, the physical properties of metal and sand listed in Table 2 were used. However, the data from these figures can be corrected to account for different kinds of sand. Figure 7 gives a correction factor, based on the thermal conductivity of the sand being used. To obtain the temperature loss for a particular sand, multiply the temperature loss, as given in Figs. 4, 5 and 6 by the correction factor,

TABLE 2

Sand Properties (from R. W. Ruddle[2])	
Thermal conductivity, Btu/hr, ft, F	0.191
Density, lb/ft³, F	91.0
Specific heat, Btu/lb, F	0.254

Metal	Specific Heat, Btu/lb, F	Constant, see Fig. 2
Aluminum	0.26	0.00406
Brass	0.12	0.00880
Steel	0.17	0.00620

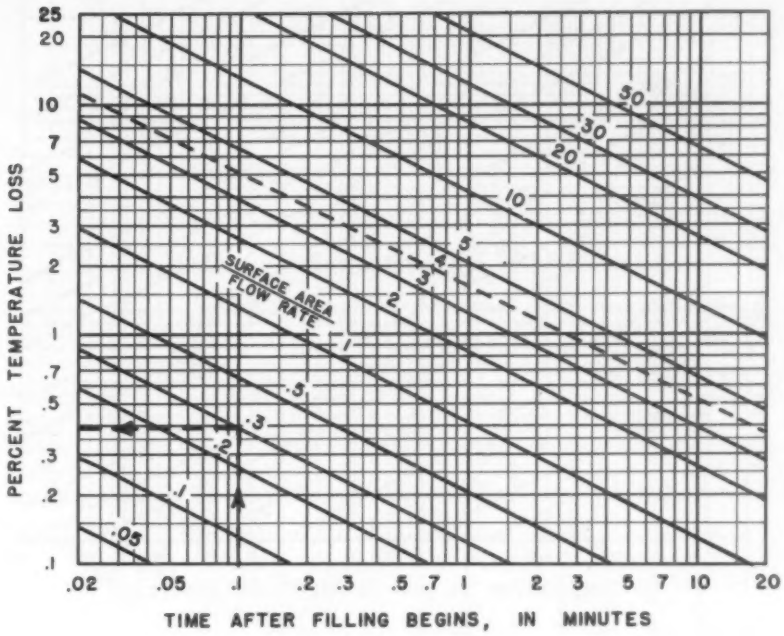


Fig. 4 — Per cent temperature loss vs. time for fixed values (marked on the curves) of the critical ratio of surface area (sq in.) to flow rate (lb/min). This figure applies to aluminum and its alloys which have a specific heat of 0.260 in sand runners (conductivity 0.191).

as given in Fig. 7, corresponding to the conductivity of the sand being used.

Another way to account for a different sand is to determine the property constant from Fig. 2 and use equation (1) or (2) directly.

EXTENDING GRAPHS TO OTHER METALS

Comparison of Figs. 4, 5 and 6 shows that the per cent temperature loss is inversely proportional to the specific heat of the metal. In other words, a metal having a specific heat two times larger than another metal will have half as much per cent temperature loss, providing the critical ratio and runner material are the same.

This means that the results for aluminum in sand runners, as given by Figs. 4 and 7, may be used as a base for other metals flowing in sand runners, if the specific heat of the liquid metal is known. This is the major advantage of expressing the temperature loss as a percentage, because then steel, copper, lead, etc., which are poured at vastly different temperatures, have the same percentage temperature loss scale and new graphs need not be drawn.

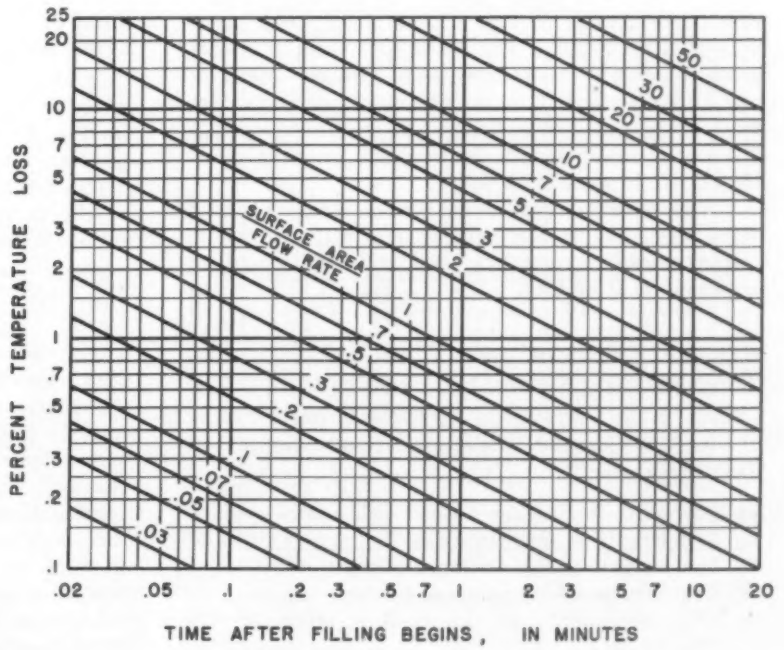


Fig. 5 — Per cent temperature loss vs. time for fixed values (marked on the curves) of the critical ratio of surface area (sq in.) to flow rate (lb/min). This figure applies to brasses which have a specific heat of 0.12 in sand runners (conductivity 0.191).

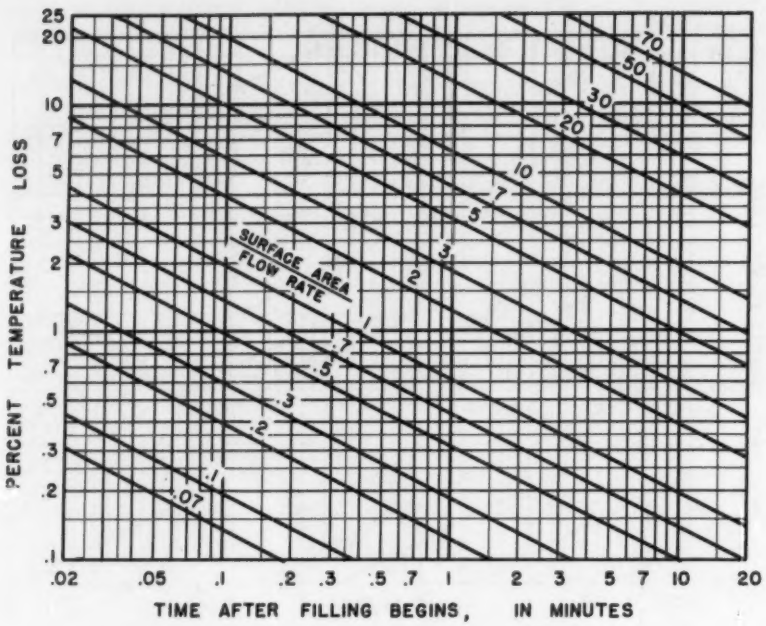


Fig. 6 — Per cent temperature loss vs. time for fixed values (marked on the curves) of the critical ratio of surface area (sq in.) to flow rate (lb/min). This figure applies to steels which have a specific heat of 0.17 in sand runners (conductivity 0.191).

For example, to obtain Fig. 5 for brass by correcting the data of Fig. 4 for aluminum, multiply the aluminum results by the specific heat of aluminum (0.26) and divide by the specific heat of brass (0.12). This gives a correction factor of 2.16. Note that all of the per cent temperature loss data in Fig. 5 for brass are 2.16 times higher than that for aluminum (Fig. 4) for the same value of the critical ratio.

Figure 8 is a plot of correction factors which may be used to determine the temperature loss for most metals in sand runners. To obtain the temperature loss in a given metal, multiply the temperature loss, as given by Fig. 4, for aluminum by the correction factor given in Fig. 8, corresponding to the specific heat of the metal being poured. Of course, a correction curve similar to Fig. 8 could have been based on Fig. 5 for brass or Fig. 6 for steel. In Fig. 8 ball park values for the specific heat of some common metals are indicated. However, more precise values may be selected from handbooks or other sources. The correction factor for the sand conductivity, given by Fig. 7, is applied as before.

An example of how these figures are to be used for a steel, having a specific heat of 0.15 Btu/lb, F, follows. Figure 6 cannot be used, since it is based on a specific heat of 0.17.

Example: Pouring of Steel Through a Sand Runner

What is the temperature of the liquid steel entering the mold cavity 0.10 min after start of filling under the conditions:

a) The perimeter of the runner is 2.5 in.
b) The length of the runner is 30 in.
c) The weight of the casting and riser is 500 lb.
d) The expected filling time is 2 min.
e) The conductivity of the sand is taken as 0.35 Btu/hr, ft, F.
f) The specific heat of the steel is taken as 0.15 Btu/lb, F.
g) The pouring temperature is 3100 F, and the mold temperature is 100 F.

From (a) and (b) multiply the perimeter by the length to obtain the surface area. This gives a surface area of 75 sq in. From (c) and (d) obtain the flow rate, which is the weight divided by the filling time. This gives a flow rate of 250 lb/min. Divide the surface area from (1) by the flow rate from (2) and obtain a critical ratio of 0.30. On Fig. 4 for aluminum, look up, for the time of 0.1 min and a critical ratio of 0.30, the per cent temperature loss, which is 0.39 per cent. When multiplied by, 3100 F minus 100 F (from g), and divided by 100, this yields an uncorrected temperature loss of 11.7 F.

On Fig. 7, look up, for the sand conductivity as given by (e), the first correction factor, which is 1.41. On Fig. 8, look up, for the specific heat of the steel as given by (f), the second correction factor, which is 1.75. Multiply the 11.7 F temperature loss from (4) by the correction factors 1.41 (5) and 1.75 (6), to get a temperature loss for steel of 28.9 F.

CONCLUSION

This presentation was limited to metals flowing in sand runners. However, the formula used to draw the charts can be applied, with some reservations, to other molds, and a similar chart can be drawn for each. However, to avoid the drawing of additional graphs, a formula is provided which includes cross combinations of all common metals with common refractory mold materials, superheat, preheat, points in time, etc. However, since symbols and dimensionless ratios are involved in the discussion of the development of the formula, it is included in the Appendix only.

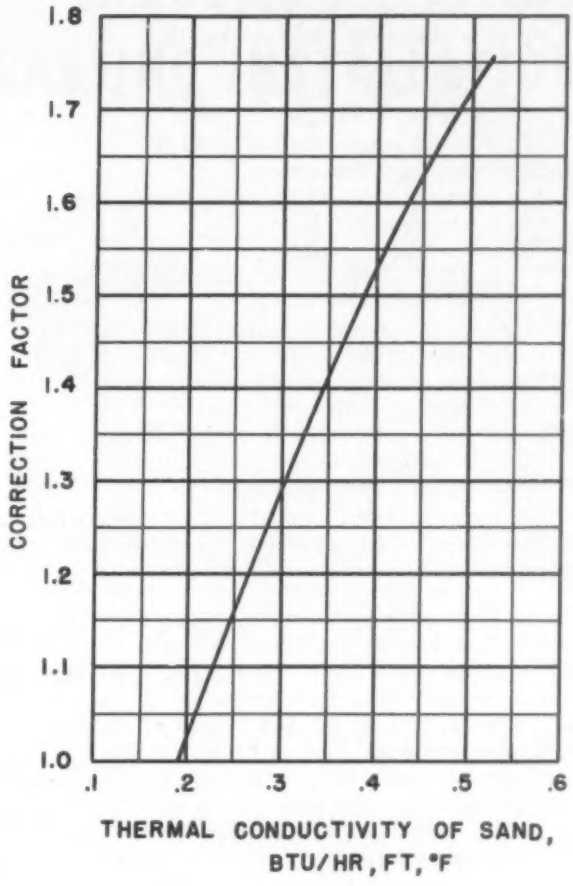


Fig. 7 — Correction factor for sands having thermal conductivities other than 0.191. Apply these corrections to Figs. 4, 5 and 6.

It is interesting to note that the formula predicts some freezing will usually take place in all runners. At the start of filling, the formula says that the temperature of the metal entering the cavity is far below the melting point, but this is impossible, because there would be plugging. The formula, then, is not applicable at the start of filling of the mold. It indicates that a frozen layer forms along the walls, which is later remelted by the upstream metal.

If the upstream metal is not hot enough to remelt this layer, the frozen thickness will usually grow and plugging takes place. Since it takes time for this layer to grow, it may be that plugging will not take place until after the cavity is partially filled. This process is quite complicated[3] and is, of course, unaccounted for in this paper. However it should be kept in mind, since the freezing and remelting will become an important factor in answering the question of whether the runner will plug.

REFERENCES

1. H. S. Carslaw and J. C. Jaeger, *Conduction in Heat Solids*, second edition, Oxford at the Clarendon Press, p. 396 (1959).
2. R. W. Ruddle, *The Solidification of Castings*, second edition, The Institute of Metals, p. 380 (sand C at 677 C) (1957).
3. "Analysis of Fluidity of Metals," by J. Niesse, M. Flemings, H. F. Taylor. Report published as part of Doctoral Requirements, Massachusetts Institute of Technology.

APPENDIX

A_c = cross-sectional area, in.^{2} (sq. in).
A_s = surface sectional area, in.^{2} (sq. in).
c = specific heat, Btu/lb, F.
k = thermal conductivity, Btu/min, in., F.

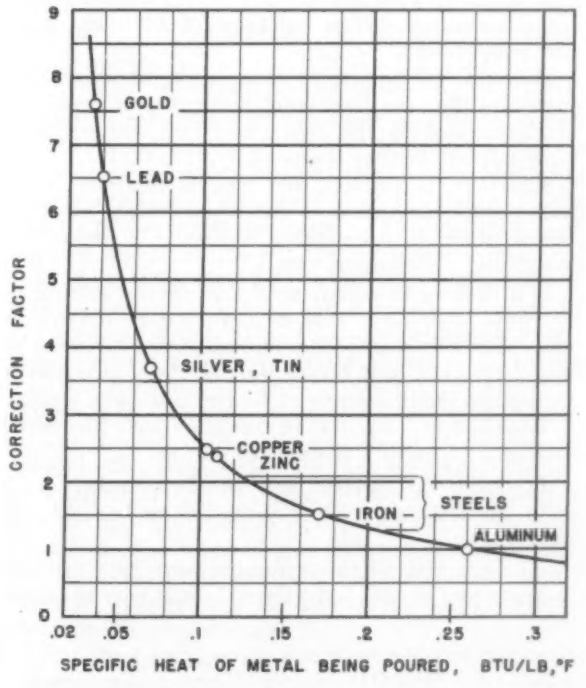


Fig. 8 — Correction factor for any metal or alloy having a specific heat other than 0.260. Apply these corrections to Fig. 4 only.

L = length of runner, in.
p = perimeter of runner, in.
p′ = perimeter of plane surface, in.
T = temperature, F.
T_e = temperature of liquid metal at exit of runner, F.
T_m = initial temperature of mold, F.
T_p = pouring temperature, F.
t = time after start of pouring (see τ), min.
W = flow rate, lb/min.
w = velocity, in./min.
x = space coordinate in direction of mass flow, in.
y = space coordinate normal to mass flow, in.
α = thermal diffusivity, in.²/min (sq in./min).
θ = dimensionless temperature loss ratio.
ρ = density, lb/in.³ (lb/cu in.).
τ = time after start of filling of mold cavity = (t − L/w), min.
ϕ = dimensionless time ratio.

Subscripts 1 — refers to mold and 2 — refers to metal.

The system equations which approximate the temperature loss in a runner may be written as

$$\frac{\delta^2 T_1}{\delta y^2} = \frac{1}{\alpha}\frac{\delta T_1}{\delta t} \qquad y>0 \quad x>0 \quad t>0 \quad (1)$$

$$T_1 = T_2 \qquad y=0 \quad x>0 \quad t>0 \quad (2)$$

$$p' k_1 \frac{\delta T_1}{\delta y} = \rho_2 c_2 A_c \frac{\delta T_2}{\delta t} + W c_2 \frac{\delta T_2}{\delta x} \qquad y=0 \quad x>0 \quad t>0 \quad (3)$$

$$T_1 = T_m \qquad y>0 \quad x>0 \quad t=0 \quad (4)$$

$$T_2 = T_p \qquad x=0 \quad t>0 \quad (5)$$

These equations describe a physical system wherein a hot fluid flows past the surface of a semi-infinite region bounded by y = 0 and x = 0. The coefficients are all constant, being independent of time, space and temperature.

Equation (1) applies to the mold material and stipulates that the heat conduction in this region is uni-directional in the y-direction and that no heat flows normal to that direction.

Equation (2) assumes that heat is perfectly transferred from the liquid to the runner wall. In other words, there is no contact resistance between the metal and the runner wall.

It is implied in equation (3) that the turbulence in the fluid is so large that no temperature differences exist in the fluid in planes normal to the direction of flow. Also, the heat conduction in the x-direction is negligibly small, compared to the transport term.

Equation (4) imposes the condition that the initial runner temperature is uniform and at T_m.

Equation (5) specifies that at the entrance (at x = 0), the temperature of the fluid is maintained constant at T_p.

The solution to this system, equations (1) to (5), is given by Carslaw and Jaeger[1] and is here rewritten as:

$$T_1 = (T_p - T_m)\,\mathrm{erfc}\left\{\frac{k_1 p' x + y W c_2}{2 W c_2 [\alpha_1 (t - x/w)]^{1/2}}\right\} + T_m \qquad (6)$$

$$T_2 = (T_p - T_m)\,\mathrm{erfc}\left\{\frac{p' x}{2 W c_2}\left[\frac{(k\rho c)_1}{t - x/w}\right]^{1/2}\right\} + T_m \qquad (7)$$

(t − L/w) is replaced by τ, since the prime concern is the temperature loss in the liquid between x = 0 and x = L, and equation (7) becomes, at x = L:

$$\frac{T_p - T_e}{T_p - T_m} = \theta = \mathrm{erf}\left\{\frac{p' L}{2 W c_2}\left[\frac{(k\rho c)_1}{\tau}\right]^{1/2}\right\} \qquad (8)$$

The assumption is now made that equation (8) applies to a closed channel, such as the runner, simply by replacing the perimeter p′ by p. Now, since p L is the surface area of the channel, equation (8) may be written as:

$$\theta = \mathrm{erf}\left\{\frac{A_s}{2 W c_2}\left[\frac{(k\rho c)_1}{\tau}\right]^{1/2}\right\} \qquad (9)$$

For brevity, let:

$$\phi = \frac{A_s}{2 W c_2}\left[\frac{(k\rho c)_1}{\tau}\right]^{1/2} \qquad (10)$$

then:

$$\theta = \mathrm{erf}\,\phi = f(\phi) \qquad (11)$$

which clearly shows that the dimensionless temperature loss is a function of one dimensionless time variable only. Therefore, the dimensionless temperature loss θ can be expressed graphically as a single curve, using ϕ as a dimensionless time variable.

Practical considerations lead to limits for θ. If the value of θ exceeded 0.25, unrealistically high losses of superheat would be implied. Values of θ below 0.001 would mean, in case of aluminum, a temperature loss in the runner of about one F, and in case of steel of about 3 F. Temperature losses below these values are practically insignificant. Within these limits one can write, with excellent approximation:

$$\theta = 1.12\,\phi \qquad 0.001 \le \theta \le 0.25 \qquad (12)$$

Then equation (9) may be written:

$$\theta = K\left[\frac{A_s}{W}\right]\frac{1}{\sqrt{\tau}} \qquad 0.001 \le \theta \le 0.25 \qquad (13)$$

where the property constant K is given by:

$$K = 0.56\,\frac{\sqrt{(k\rho c)_1}}{c_2} \qquad (14)$$

Figure 2 is a plot of equation (14), using a density of 91 lb/cu ft, and a specific heat of 0.254 Btu/lb, F.

Of course, any numerical values for the parameters may be inserted into equation (13), corresponding to any combination of mold and metal, runner geometry, etc. This equation should apply well for all common metals in sand runners, but for metal-walled runners, the effect of the boundary conductance as well as freezing and remelting may perhaps not be negligible.

If in equation (13) the mass rate of flow W is replaced by the product of velocity w, the cross-sectional area A_c and the density ρ, one finds that for any given metal and mold, the temperature loss at all times τ is proportional to the ratio of surface to cross-sectional area, and inversely proportional to the linear velocity.

INDUCTION MELTING AND DEGASSING INSTALLATION

by O. E. Erickson

ABSTRACT

The details of the induction vacuum equipment at the author's company are described, and the benefits received in the details of making a heat are given.

INTRODUCTION

The facilities that were available at the author's company prior to the addition of the induction melting and degassing furnaces were two 8000 lb and one 3000 lb acid-lined arc furnaces. These were utilized for production of stainless steel, carbon steel and other low alloys. This foundry, like many others, is faced with the problems of processing a high proportion of revert materials, and also of providing a means of processing small heats of special analyses.

These two requirements led to an extensive investigation of the commercial melting equipment available, and to the eventual installation of the induction melting and degassing equipment. With this installation the company has been able to realize these advantages:

1) For over one year stainless steel has been produced with a gas threshhold level below that required to produce castings free from pinhole porosity when cast in green sand molds. This has been effected without inordinate control over mold moisture content, pouring temperature or the use of special deoxidizing materials such as selenium.
2) A second major advantage that came with the use of the induction furnace has been the elimination of the need for wash heats to clean up furnaces to prevent contamination of subsequent heats. With the induction furnaces, various furnace shells are utilized for each major category of melt chemistry produced.
3) A third advantage results from the ability to produce heats consisting of 100 per cent revert.

The accumulative affects of these three advantages have resulted in a reduction of heats out of specification and losses attributed to high gas content, and have provided final products more acceptable to the ultimate user.

This induction melting vacuum degassing installation consists of a 300 kw induction melting unit with two one ton furnaces arranged and modified so that a vacuum degassing chamber may be placed over either furnace. The induction unit, rated 300 kw, is the recently introduced static frequency converter which, by means of a certain type of transformer design, converts 3-phase, 60-cycle power to 180 cycle single phase of about 750 volts.

The converter consists of a cubicle containing a power unit with 60-cycle capacitors for maintaining a line power factor of about 0.90 or better. A second cubicle contains the furnace control, and consists of the usual capacitors for resonating the coreless furnaces and auxiliary components. Two meters are used for observing applied power. A set of push buttons and rotary switch are provided for controlling the power into the furnace. A two-position selector switch in the base of the control panel permits the operator to select one of two furnace positions for operation.

Two furnace stands are provided, each adequate to support a furnace case of sufficient size for a 3000 lb melt. However, at present the furnaces have coils of size to handle normal 2000 to 2400 lb melts.

These furnaces are mounted on special fabricated bases, which are dish shaped and flanged to form the base of the closed vacuum degassing chamber when used as such. The furnace stations are located in pits in front of the control panel to facilitate handling of the charges and the vacuum degassing chamber (Fig. 1). This equipment can be used as normal air melting furnaces at any time without involving the use of any vacuum equipment, if desired.

The vacuum degassing equipment is essentially a large steel chamber or bell jar lowered over the air melting furnace and sealed to the specially fabricated base plate (Figs. 2 and 3). Proper manifolding, valves and a pump, permit application of vacuum to either furnace station as may be desired by the operator.

DEGASSING CHAMBER

The vacuum degassing chamber is a plain carbon steel tank approximately 3/8-in. in thickness with a double walled water cooled dome. A large O-ring seal is maintained in a groove in the flange on the bottom of the degassing chamber. This insures a good vacuum seal when the chamber is lowered on to the base plate. This degassing chamber is approximately 8 ft in diameter, 8 ft high and is moved by means of an overhead crane. The base also contains sealed power ports for entrance of the power leads to the vacuum ports.

When the vacuum equipment is not used, a protective guard is placed over the flange of the base to prevent any damage while air melting. Pneumatically operated valves are included to enable the operator to select either station as desired for the application of vacuum. A filter or trap is included in the vacuum line in order to prevent metallic or refractory particles from impinging on the moving parts of the pump which would cause damage.

Vacuum is obtained by use of an 850 cfm mechanical pump driven by a 40 hp motor. Theoretically, with a clean dry system, this pump would be capable of

O. E. ERICKSON is Vice-Pres., Hanford Foundry Co., San Bernardino, Calif.

reducing the pressure to 200-500 microns in about 10 to 15 min.

For indications of vacuum conditions in the processing chamber, or for independent performance checking of the mechanical pump, a two-station automatic gage is included. The stations are located so that chamber pressure and pump performance may be monitored. This gage has an indicating range from 0 to 100 mm mercury.

The furnaces are lined with a high MgO contact refractory and the material is rammed dry using a transite form. The first heat is held 20 min at 3150 F (1732 C) to sinter the lining. It is then cooled back to 2900 F (1593 C), vacuum boiled and used as a production heat. The furnaces average 50 heats per lining when melting stainless at 3150 F (1732 C).

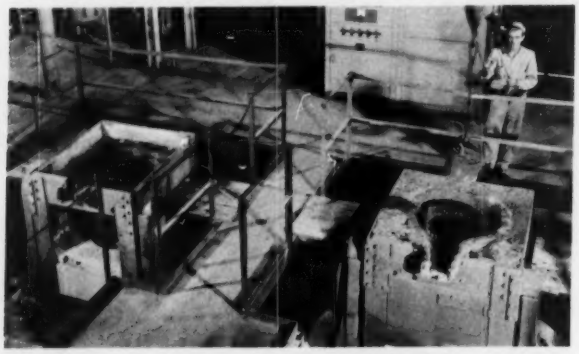


Fig. 1 — The furnace stations are located in pits in front of the control panel to facilitate handling of the charges and the vacuum degassing chamber.

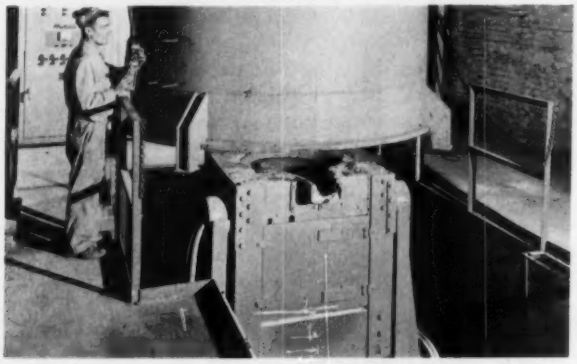


Fig. 2 — The vacuum degassing equipment, essentially a large steel chamber, is lowered over the air melting furnace.

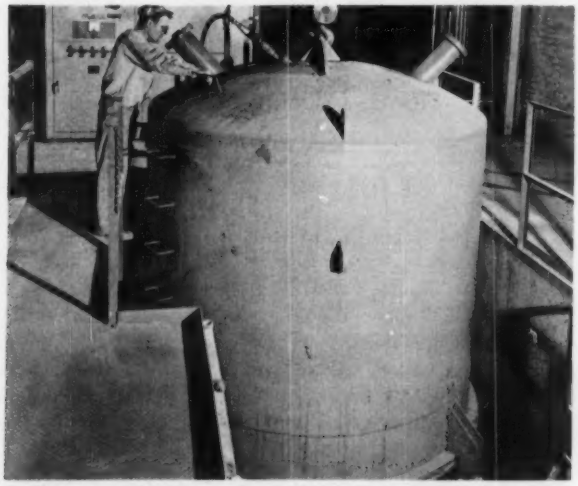


Fig. 3 — When the vacuum degassing equipment has been lowered into place, it is sealed to the specially fabricated base plate.

The making of a heat consists of melting, adjusting the carbon to allow for the removal of 0.06 to 0.12 per cent carbon, heating to 2950 F (1621 C), vacuum degassing, heating to 3150 F (1732 C), adjusting the silicon and manganese and tapping into a teapot ladle.

The charge may consist of 100 per cent revert material such as the 11.5 to 14.00 per cent chrome grade known as A.C.I. CA 15. After a meltdown an analysis is taken, and carbon added to give a bath with approximately 0.20 per cent carbon.

When a temperature of 2950 F (1621 C) is reached, the bell is lowered over the furnace and the vacuum pump started. The air admittance valve is fully open, and the operator controls the height of the boil by opening or closing this valve. The time consumed will be from five to 12 min, depending on the melt in carbon and the carbon required by the specification.

After this period the vacuum pump is shut down, the air admittance valve opened, and when atmospheric pressure is reached the bell removed. A sample is then taken to determine the carbon and chromium, and the necessary additions of these elements are made plus 0.50 per cent silicon and 0.50 per cent manganese. The melt is superheated to 3150 F (1732 C), 0.10 per cent aluminum is added and the furnace tapped.

The next heat is made faster by pouring 200 to 300 lb of metal back into the furnace to serve as a molten starter. The procedure for the austenitic and other grades of stainless is exactly the same except no aluminum is used.

CONCLUSION

No figures are available regarding the exact amount of hydrogen, nitrogen or oxygen removed by this process. Test bar results indicate that the tensile and ductility are no better than a well made arc furnace heat. However, the average ductility is better, indicating that it is perhaps easier to make a top quality stainless heat by vacuum degassing than in the arc furnace.

The equipment can also be used for melting under an inert atmosphere such as argon. Consideration is also being given to pouring in an argon envelope and using argon for purging the mold.

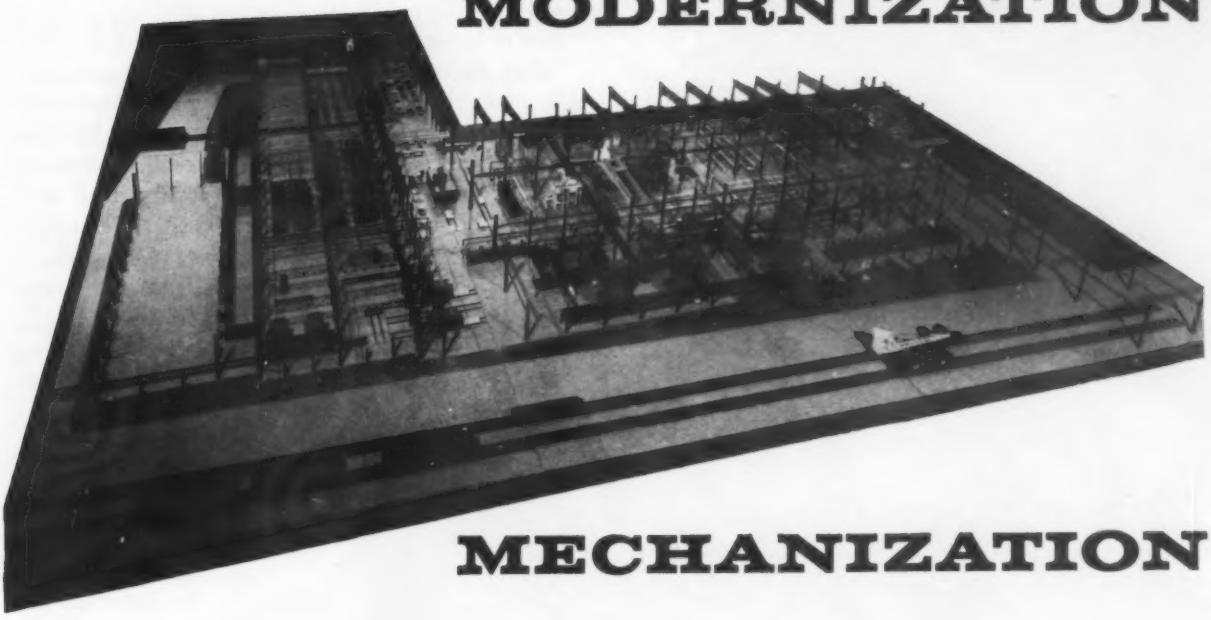
Heats are also being made by dead melting in the arc furnace, pouring into the induction and vacuum boiling. Metal such as the CA 15 (11 to 13 chrome grade) dead melted under the arc would always be gassy, probably from hydrogen pickup and nitrogen fixation under the arc. After vacuum boiling the metal is never gassy.

Over 1,000 heats have been made using the vacuum to lower the pressure sufficiently to cause a carbon-oxygen reaction in the presence of high chromium. No castings have shown evidence of pinhole porosity or gassiness. The average physical properties are raised and the efficacious use of revert is accomplished.

This tool has become an aid in efficient production and quality improvement.

A timely message for foundry managements

MODERNIZATION



MECHANIZATION

AUTOMATION

This model, a proposed modernization of a steel foundry producing railroad, armor and commercial castings, is an example of Knight professional foundry engineering. Operations are automated, semi-automated and mechanized to provide, insofar as is practicable, a flow of material through the plant with minimum handling, except when an operation is performed. Production per man hour has been increased, more flexibility has been provided, control of quality and delivery has been improved, plus the opportunity for lower operating costs.

This program resulted from a survey by Knight Engineers working with client personnel to determine, for this problem, the most modern technological improvements and new materials, methods and controls that could be economically justified.

KNIGHT SERVICES INCLUDE:

Foundry Engineering • Construction Management • Modernization • Mechanization • Automation • Survey of Facilities • Materials Handling • Methods • Industrial Engineering • Wage Incentives • Cost Control • Standard Costs • Flexible Budgeting • Production Control • Organization • Marketing

Lester B. Knight & Associates, Inc.

Management Consultants, Industrial and Plant Engineers

Member of the Association of Consulting Management Engineers, Inc.

549 W. Randolph Street, Chicago 6, Illinois

New York Office—Lester B. Knight & Associates, Inc., Management Consultants, 500 Fifth Ave., New York 36
20111 James Couzens Highway, Detroit 35, Michigan
Knight Engineering A.G. (Zug), Zurich Branch, Dreikönigstrasse 21, Zurich, Switzerland
Lester B. Knight & Associates, G.M.B.H., Berliner Allee 47, Düsseldorf, Germany

Circle No. 159, Pages 145-146

"ROYERATED" SAND IS THE FINEST BLENDED AND AERATED SAND YOU'LL EVER SEE!

You're looking at the "business" end of a machine that for some 40 years has given foundrymen everywhere the best in blended and aerated sand. SAND SEPARATORS AND BLENDERS use a unique "combing belt" principle (we call *Royeration*) that combines combing of the sand with thorough churning, mixing and cooling. These machines—for any size foundry—available as portable or stationary, hand-shovel, tractor-bucket feeding or mechanized "in-line" installations. Capacities from 4 to 180 tons/hour. *New bulletin #SS-60 tells all.* Get all the specs, facts by contacting us. Royer Foundry & Machine Co., 155 Pringle Street, Kingston, Penna., phone BUtler 7-2165.

ROYER

ROYER FOUNDRY & MACHINE CO.

All-Time High in Exhibitor Response Assures Outstanding Equipment Show

Applications for space in the 1962 AFS Exposition at Detroit's Cobo Hall have all but swamped AFS headquarters during the past month.

A record number of metalcasting suppliers made early reservations for the big show held in conjunction with the 66th AFS Castings Congress and the 29th International Foundry Congress —a double-barreled attraction.

Metalcasting's key role in the nation's defense economy is one factor which spurred the suppliers to an extra effort this year. They recognize that the exposition and Congress is the one and best place to contact the industry's key personnel. Added to this is the fact that Cobo Hall is the nation's newest and largest trade exposition hall so centrally located. It offers downtown convenience and unparalleled exhibitor facilities.

The striking "Red Carpet" leading to a six billion dollar market has been given added significance by the huge preparedness program now underway in this country. The role of the metalcaster will call for expanded efforts.

The exposition offers an opportunity to show new products and techniques which will enable foundries to compete with other fabrication methods.

Exhibitors as of September 1 are:

Ajax Magnethermic Corp.
Allied Chemical Corp., Semet Solvay Div.
Allied Iron Co.
Alloy Metal Abrasive Co.
Alpha-Lux Co.
American Air Filter Co.
American Colloid Co.
American Fire Clay & Products Co.
American Foundry Flask Co.
American Foundrymen's Society
American Smelting and Refining Co.
Apex Smelting Co.
Archer-Daniels-Midland Co.
Aristo Corp.
Associated Foundry Services, Inc.

Baird-Atomic, Inc.
Baroid Chemicals, Inc.
Bartlett-Snow-Pacific, Inc.
Beardsley & Piper Div., Pettibone-Mulliken Corp.
Bellows-Valvair
Beryllium Corp.
British Moulding Machine Co. Ltd.
Brown Boveri Corp.

Campbell-Hausfeld Co.
Carborundum Co.
Cardox Div., Chemetron Corp.
Carver Foundry Products
Catalytic Combustion Corp.
Centrifugal Casting Machine Co.
Chain Belt Co., Carrier Div.
Clearfield Machine Co.
Cleveland Vibrator Co.
Corn Products Sales Co.
Crownflex Abrasives Wheel Mfg. Corp.

Davis Fire Brick Co.
Dayton Oil Co.
Demmler Mfg. Co.
Detroit Electric Furnace Div., Kuhlman Electric Co.
Deynor Corp.
Harry W. Dietert Co.
Joseph Dixon Crucible Co.
Durez Plastics Div., Hooker Chemical Corp.

Electro Refractories & Abrasives Corp.
Encyclopedia Britannica, Inc.
EPIC, Inc.
Exomet, Inc.

Fanner Mfg. Co.
FOSECO, Inc.
Foundry
Foundry Equipment Co.
Fox Grinders, Inc.
Fremont Flask Co.

General Dynamics Corp., Liquid Carbonic Div.
General Refractories Co.
Great Lakes Carbon Corp., Electrode Div.
Great Lakes Foundry Sand Co.

Hanna Furnace Corp.
Benj. Harris & Co.
Herman Pneumatic Machine Co.
Hickman, Williams & Co.
Hill & Griffith Co.
Hines Flask Co.
E. F. Houghton & Co.

Illinois Clay Products Co.
Indianapolis Wire Bound Box Co.
Inductotherm Corp.
International Automation Corp.
International Graphite & Electrode Div., Speer Carbon Co.
International Minerals & Chemical Corp.
International Molding Machine Co.
International Nickel Co.

Jarrell-Ash Co.
Jeffrey Mfg. Co.

Kaiser Refractories & Chemicals Div.
Kindt-Collins Co.
Lester B. Knight & Associates, Inc.
Koppers Co.
H. Kramer & Co.

Laboratory Equipment Corp.
Lava Crucible-Refractories Co.
R. Lavin & Sons, Inc.
Lindberg Engineering Co.

J. S. McCormick Co.
Magnaflux Corp.
Magnet Cove Barium Corp.
Manley Sand Div., American-Marietta Co.
Martin Engineering Co.
Metal & Thermit Corp.
Metallizing Company of America, Inc.
Milwaukee Chaplet & Mfg. Co.
MODERN CASTINGS
Modern Equipment Co.
Moulders' Friend

Nassau Smelting & Refining Co.
National Acme Co., Shalco Div.
National Carbon Co.
National Crucible Co.
National Engineering Co.
National Foundry Sand Co.
National Metal Abrasive Co.
Newaygo Engineering Co.
North American Smelting Co.
Northwest Olivine Co.

S. Obermayer Co.
Ohio Ferro-Alloys Corp.
Osborn Mfg. Co.

Pangborn Corp.
Pickands Mather & Co.
Planet Corp.
Pyrometer Instrument Co.

Redford Iron & Equipment Co.
Reichhold Chemicals, Inc.
Ren Plastics, Inc.
Republic Steel Corp.
Roessing Bronze Co.
Royer Foundry & Machine Co.

Sand Products Corp.
Claude B. Schneible Co.
I. Schumann & Co.
Scientific Cast Products Corp.
Security Alloys Co.
Shaw Process Development Corp.
Simplicity Engineering Co.
Sipi Metals Corp.
G. E. Smith, Inc.
Spencer Turbine Co.
SPO, Inc.
Stahl Specialty Co.
Standard Electrical Tool Co.
Sterling National Industries
Frederic B. Stevens, Inc.
Superflux Mfg. Co.

Taccone Corp.
G. H. Tennant Co.

Union Carbide Metals Co.
Union Carbide Plastics Co.
Unicast Development Corp.
U. S. Gypsum Co.
U. S. Reduction Co.

Vanadium Corp. of America
Vesuvius Crucible Co.

A. T. Wagner Co.
Wheelabrator Corp.
Whirl-Air-Flow
Whitehead Brothers Co.
White Pine Lumber Co.
Whiting Corp.
Williston & Co.

METALCASTING NEWS

Regionals Stress Technology

Apprentice Contest Opens

Metalcasting Sales Seminar Report

Board Action Paves Way for Expansion of Broad T&RI Education Program

Expansion of the AFS Training & Research Institute program has been approved by the Board of Directors. The action opens the way for greatly broadened activities in training, retraining, and research.

Metalcasting leaders have long maintained that the future of the industry is keyed to the solving of three basic problems. These are:

(1) Continuous and adequate retraining of technical and supervisory personnel.

(2) A centralized program for an estimated 200,000 persons expected to enter the industry in the next 25 years.

(3) Centralized administration and facilities for basic research.

The training and retraining of personnel, although highly successful, has been conducted on a limited basis through AFS Training and Research Institute courses. More than 2000 persons from 750 companies have attended the 60 courses presented throughout the country. However, AFS President A. L. Hunt estimates that a minimum of 6000 should be trained yearly.

An important part of the program, and one involved in all three phases, is the $600,000 National Foundry Training Center in Des Plaines, Ill. Architectural plans have been completed and land donated by the Society.

When completed, the Center will be equipped both for training and research activities. As an independent foundation it will permit major expansion of basic research activities for the entire industry.

It has been emphasized that the establishment of the Center will not affect the current or contemplated basic research projects.

Says President Hunt, "The Institute will continue to assign and conduct its research projects wherever maximum effort per research dollar can be obtained. Undoubtedly the facilities of the Institute will be of great help, especially for carrying on 'do-it-yourself' experiments under the direction of AFS committees on a variety of foundry subjects."

Regional Conferences Advance Technology

Advancement of the foundry industry through new technology will be stressed at four regional conferences in October. Two conferences were held in September and three are scheduled for early 1962.

The meetings, sponsored by local AFS chapters, feature many speakers heard at the 65th AFS Castings Congress held in San Francisco. In addition, local speakers discuss common area problems. Highlights of the conferences are presented here:

The remaining conferences:

Oct. 5-6	**Ohio Regional**
Netherland Hilton	Cincinnati
Oct. 13-14	**New England**
M.I.T.	Cambridge, Mass.
Oct. 19-20	**Michigan**
Michigan State Univ., E. Lansing, Mich.	
Oct. 26-27	**Purdue**
Purdue Univ.	Lafayette, Ind.
Feb. 8-9	**Wisconsin**
Hotel Schroeder	Milwaukee
Feb. 15-16	**Southeast**
Thomas Jefferson Hotel, Birmingham, Ala.	
March 15-16	**Texas**
Menger Hotel	San Antonio, Tex.

George H. Sheppard, director of research and training, DoAll Co., discusses sawing operations with T&RI Training Supervisor, R. E. Betterley. A comprehensive course on cleaning room problems will be conducted by AFS at Chicago's La Salle Hotel, Nov. 1-3.

Emphasize Techniques at Ohio Conference

New techniques will theme the 9th Ohio Regional Foundry Congress, Oct. 5-6, at the Netherland-Hilton Hotel, Cincinnati. General and sectional meetings will be held both days.

THURSDAY, OCT. 5

(Morning Sessions)

"The Use of Furans in the Foundry," Joseph P. Cummins, International Harvester Co., Indianapolis; George Bivans, Standard Steel Works, Burnham, Pa.; Wayne Buell, Aristo Corp., Detroit; Robert J. Mulligan, Archer-Daniels-Midland Co., Cleveland.

(2:00 p.m. Sessions)

"The Use and Problems of Fine Synthetic Sands on Aluminum and Bronze Castings," George Schultz, Reliable Castings Corp., Cincinnati.

"How to Louse Up a Cupola," T. E. Barlow, Eastern Clay Products Div., International Minerals & Chemical Co., Skokie, Ill.

"A Study of Rammed Mold Hardness Versus Casting Dimensions," Joseph Schumacher, Hill & Griffith Co., Cincinnati.

"Design and Engineering of Hot Box Coreboxes," Ernest Harkess, Ford Motor Co., Cleveland.

(3:00 p.m. Sessions)

"Surface Finish as a Selling Point," James Voss and Joseph Leverton, Hamilton Foundry Co.,

SERVICE COMES FIRST • DON'T SETTLE FOR LESS • WHAT DOES R & D MEAN TO YOU? •
SO YOU WANT IT TODAY • HE HAS TO LIKE A 24-HOUR WORKING DAY • DID YOU SAY SERVICE? •

we've said our piece about VCA service

now you tell us

VCA "SERVICE COMES FIRST" CONTEST

You've seen the ads. You've read the story of VCA's "extra-value-through-extra-service" policy. You're aware of the importance to the industry and to your company of VCA's fully integrated operation, R&D program, complete product line, strategically located plants, and all the other things we've discussed. But there's one thing the ads couldn't cover ...how VCA Service has helped you specifically. So, we're running a contest...a contest to get you to tell us.

Who Can Enter. The VCA "SERVICE COMES FIRST" CONTEST is open to anyone who has benefited from VCA service...researchers, PA's, production men, engineers, melters, even presidents.

How To Enter. Simply write a letter describing how VCA SERVICE has at some time or other helped you or your company solve a problem, cut costs, do a better job or make a better product. Tell us how, why, when, where, and for whom. Letters may be handwritten or typed, and may be of any reasonable length. Sketches, photographs or other supporting evidence may be included.

Prizes.

1st. FIVE — $100 U. S. Gov. Bonds, Series E
2nd. FIVE — $50 U. S. Gov. Bonds, Series E
3rd. FIVE — $25 U. S. Gov. Bonds, Series E

Additional Prizes.

4th. $100 U. S. Gov. Bond, Series E
5th. $50 U. S. Gov. Bond, Series E
6th. $25 U. S. Gov. Bond, Series E
7th. $25 U. S. Gov. Bond, Series E
8th. $25 U. S. Gov. Bond, Series E
9th. $25 U. S. Gov. Bond, Series E
10th. $25 U. S. Gov. Bond, Series E

Bonus Prizes.
100 Stainless Pens for first 100 letters received. In the case of a tie, judges will award duplicate prizes.

Judges. The VCA "SERVICE COMES FIRST" CONTEST will be judged by a distinguished panel chosen from editorial, university, association and industry sources. Names will be announced at a later date.

Get More Information at the METALS SHOW. "SERVICE COMES FIRST" will be the theme of VCA's booth at the Metals Show. For more information about the contest, visit VCA Booth No. 338 at the show, being held this year in Detroit, Mich., October 23-27.

Closing Date. Entries must be mailed to VCA "SERVICE COMES FIRST" CONTEST
Vanadium Corporation of America
420 Lexington Ave., New York 17, N. Y.
and postmarked no later than November 20, 1961. Entries become the property of VCA and cannot be returned.

Winners will be announced on December 20, 1961. Bonds will be registered in the winners' names and forwarded immediately.

DON'T DELAY...ENTER TODAY

VANADIUM CORPORATION OF AMERICA
420 Lexington Avenue, New York 17, N. Y.
Chicago • Cleveland • Detroit • Pittsburgh

Circle No. 175, Pages 145-146

Hamilton, Ohio.

"Inclusions in Aluminum Alloy Castings," J. M. Fox, Aluminum Co. of America, Cleveland.

"Machined Patterns Can Be Competitive," Ray Olson, Southern Precision Pattern Works, Inc., Birmingham, Ala.

"Specifications Requirements for Production of Steel Castings," Glenn Hughes, Ohio Steel Foundry Co., Springfield, Ohio.

(Evening Session)

"Why Not Sell and Increase the Use of Castings," W. G. Gude, Penton Publishing Co., Cleveland.

FRIDAY, OCT. 6

(9:00 a.m. Sessions)

"The Practical Application of Statistical Quality Control in the Foundry," Ben Frazer, American Standard Corp., Cincinnati.

"Ceroxides—A Study of Steel Foundry Sands—Investigation of Snotters and Junk," J. B. Caine, Cincinnati.

"Vacuum Degassing & Melting—All Metals," William Johnson, Shenango Furnace Co., Dover, Ohio.

"Problems in Ductile Iron," David Matter, Ohio Ferro-Alloys Corp., Canton, Ohio.

(10:45 a.m. Sessions)

"Kiss Gating Brass Castings," C. W. Ward, Jr., American-Standard Corp., Cincinnati.

"Foundry Trends Challenge the Pattern Industry," Walter Siebert, Cleveland Standard Pattern Works, Cleveland.

"Metal Analysis Relationship with Brinell Hardness," Frederick Kasch, Gray Iron Research Institute, Cleveland.

"Malleable and Pearlitic Annealing and Heat Treating," Ralph Davis and Eugene Baker, Ironton Div., Dayton Malleable Iron Co., Ironton, Ohio.

(1:45 p.m. Sessions)

This will be a panel discussion of trends in casting tolerances airing the views of buyers and foundrymen. Speakers will be: Harry Kindle, Cummins Diesel Engine Co., Columbus, Ind.; S. A. McCarthy, McDonnell Aircraft Corp., St. Louis; Charles F. Walton, Gray Iron Founders' Society, Cleveland; Herbert F. Scobie, Non-Ferrous Founders' Society, Evanston, Ill.; Paul E. Eubanks, Ohio Steel Foundry Co., Springfield, Ohio; C. R. Baker, Albion Malleable Iron Co., Albion, Mich.

Harry E. Placke, Sidney Aluminum Products, Inc., Sidney, Ohio, is chairman of the program committee. Norman J. Stickney, Sand Products Co., Cleveland, is vice-chairman. Other members are Walter Smith, Shenango Furnace Co., Dover, Ohio; Myron E. Boyd, Maumee Pattern Works, Toledo, Ohio, and Paul E. Eubanks, Ohio Steel Foundry, Springfield, Ohio.

The conference is sponsored by the Cincinnati, Central Ohio, Toledo, Canton and Northeastern Ohio Chapters.

Starts Die Casting Shop

Dycast, Inc., Skokie, Ill., a die casting plant, has started operations recently.

Study Joint Aluminum Plan

Cerro Corp., New York, and Bridgeport Brass Co., Div. National Distillers & Chemical Corp., are jointly studying the feasibility of an aluminum reduction plant of 56,000 tons annual capacity at Wauna, Ore. Both National Distillers and Cerro have metal fabricating plants producing aluminum mill products.

Eastern Co. Diversification

Eastern Co., Naugatuck, Conn., formerly Eastern Malleable Iron Co., completed the second major acquisition this year in its production-marketing group approach to diversification in growth fields.

The company purchased Thompson Materials Corp., Belleville, N. J., the northeast's largest supplier of specialty products to the highway and heavy building construction markets. Thompson has been selling malleable highway contraction joints manufactured by Frazer & Jones Div. of Eastern in Syracuse, N. Y.

Earlier this year Eastern expanded into the marine field by acquiring Wilfrid O. White & Sons, Inc., nautical instrument manufacturer, and merging it with Eastern's Danforth Anchor Div. acquired in 1959 and relocated in Portland, Me.

The division at Naugatuck, Conn., has been renamed Alloy Foundries. Another foundry division, Eastern Casting Corp., Newburgh, N. Y., produces permanent mold aluminum castings and aluminum die castings. Eastern Sales Div., Pittsburgh, Pa., handles sales and distribution of metal products of various divisions.

Olin Mathieson Announces Huge Expansion Program

A multi-million dollar program to modernize brass operations and raise production capacity was announced by Olin Mathieson Chemical Corp.

Scheduled to be completed in early 1964, the program will include construction of an entirely new brass and copper casting and rolling plant in East Alton, Ill.; replacement and modernization of various finishing mills, annealing, slitting and other facilities at the present Olin Brass Mills at East Alton and at New Haven, Conn., as well as modernization of brass fabricating facilities.

Detroit Convention Committee

Activities of the Detroit Chapter are well underway for its role as host chapter to the 66th AFS Castings Congress and Exposition. The 29th International Foundry Congress will be held simultaneously May 7-11 in Cobo Hall. At the upper left is General Convention Chairman Jess Toth. Below are Honorary Convention Chairman C. W. Hockman, Detroit Vice-Chairman G. J. Rundblad, Jr., and Detroit Chairman R. H. Sutter.

Michigan Conference Stresses Progress

A critical look at new foundry developments will be stressed at the Michigan Regional Foundry Conference, to be held Oct. 19-20 at Kellogg Center, Michigan State University, East Lansing, Mich. A tour of the Oldsmobile plant in Lansing is the concluding event.

The conference is sponsored by the AFS Central Michigan, Detroit, Saginaw Valley and Western Michigan Chapters with Michigan State University and the University of Michigan Student Chapters.

J. R. Young, Cadillac Motor Car Div., Detroit, is general conference chairman. Donald Dice, Albion Malleable Iron Co., Albion, Mich., is program chairman. John E. DeGroot, Benfur Engineering Co., Grand Rapids, is secretary. Eugene Passman, Frederic B. Stevens, Inc., Detroit, is treasurer, and Jess Toth, Harry W. Dietert Co., Detroit, is the permanent executive secretary and treasurer.

The tentative program:

THURSDAY, OCT. 19

Morning Sessions

Registration will start in the main lobby at 8:30. The call to order will be made by Conference Chairman J. R. Young followed by a welcome by the Central Michigan Chapter Chairman J. E. Grabbert, Gale Mfg. Co. A panel will discuss future trends in casting tolerances. Speakers: "Metal Composition," R. W. Gardner, Ford Motor Co.; "Molding Techniques," T. R. Schroeder, Pontiac Motor Div.; "Coremaking," F. J. Hodgson, Eaton Mfg. Co.; "Pattern Equipment, V. A. Pyle, Pyle Pattern & Mfg. Co.; "Machine Shop Requirements," C. W. Yaw, Cadillac Motor Car Div.

Afternoon Sessions

"Management vs Compensation Problems," will be discussed at luncheon meeting by F. A. Warner, Auto Owners, Inc. Other talks include "Hot and Cold Box Coremaking Using Chemical Setting Core Binders," Joseph Cummings, International Harvester Co.; "Hydraulic Approach to Gating," J. F. Wallace, Case Institute of Technology; "Mold Control in Medium Sized Foundries," T. H. Hanna, Harry W. Dietert Co. and A. F. Tankovich, Midwest Foundry Co. The annual banquet will be held at the Hotel Jack Tar.

As anyone can tell you, people (especially wife-type people) dislike being taken for granted.

Yet in a busy manufacturing plant, production schedules depend on the taken-for-granted reliability of all equipment (but especially materials handling equipment).

Whiting materials handling systems are the result of years of engineering improvements and refinements. A crane, like the one above, is thoughtfully engineered and carefully constructed so that its unobtrusive dependability can be taken for granted day in and year out.

Let us tell you about Whiting Cranes. Write: Whiting Corporation, 15650 Lathrop Ave., Harvey, Ill. In Canada: Whiting Corporation (Canada) Ltd., 350 Alexander Street, Welland, Ontario, Canada. Ask for bulletin: "How to Select An Overhead Traveling Crane."

See our catalog in Sweets

90 OF AMERICA'S "FIRST HUNDRED" CORPORATIONS ARE WHITING CUSTOMERS

CRANES WHITING

MANUFACTURERS OF CRANES; TRAMBEAM® HANDLING SYSTEMS; PRESSUREGRIP; TRACKMOBILES®; FOUNDRY, RAILROAD AND SWENSON CHEMICAL PROCESSING EQUIPMENT

Circle No. 161, Pages 145-146

FRIDAY, OCT. 20
Morning Sessions

Registration starts at 8:00 a.m. Sessions include "New Market Opportunities for Metal Castings," Jack H. Schaum, editor, MODERN CASTINGS; "A New Look at Plastic Patterns for High Production," Robert Simon, Central Foundry Div.; a student session, "Challenge of the Foundry Industry to the College Student," R. Dobbins, Albion Malleable Iron Co.; and group discussions on various metals and operations.

Speakers and their subjects include "Ductile Iron," James Graham, Ford Motor Co.; "Malleable Iron," Price Burgess, Albion Malleable Iron Co.; "Cupola Operation," Richard Dixon, Cadillac Motor Car Div.; "Shell Molding," William Suttles, Beardsley Piper Div., Pettibone Mulliken Corp.; "Dies, Molds, Patterns," John Zatalokin, Monarch Pattern Co.; "Ferrous Castings," David Sherman, Engineering Castings, Inc.; "Foundry Sands," Charles Cousineau, Carpenter Bros., Inc. "Non-Ferrous Castings," Kenneth Nelson, Wellman Bronze & Aluminum Co.; "Plant Engineering and Maintenance," Dale Brautigam, West Michigan Steel Castings Co.

AFS Regional Vice-President T. T. Lloyd, Albion Malleable Iron Co., will speak at the luncheon, discussing the foundry program at Western Michigan University.

The Oldsmobile plant tour will be held from 1:30 to 3:30.

New England Sets Costs-Cutting Theme

Cost control through modern practices is the theme of the New England Regional Foundry Conference scheduled at Kresge Auditorium, Massachusetts Institute of Technology, Cambridge, Mass., Oct. 13-14.

Co-Chairmen are P. C. Smith, General Electric Co. and L. W. Greenslade, Brown & Sharpe Mfg. Co. Chairmen for the ferrous sessions are William Sommer, Plainville Casting Co., and Dale Watterhouse, Grinnell Corp. Chairmen for the non-ferrous sessions are E. F. Tibbetts, Wellaston Brass & Aluminum Foundry, Inc., and AFS Regional Vice-President R. R. Ashley, American Radiator & Standard Sanitary Corp.

Sponsors are the New England, Connecticut, Wentworth Student, and M.I.T. Student Chapters of AFS, as well as Massachusetts Institute of Technology, Northeastern University, Tufts University, Connecticut Foundrymen's Association, Connecticut Foundrymen's Association (Boston Chapter), Connecticut Non-Ferrous Foundrymen's Association, Providence Non-Ferrous Foundrymen's Association, and Pine State Foundrymen's Association.

General sessions include: "How to Attract People Into the Foundry," F.E.F. president David H. Morgan; "Labor Relations in the Foundry Industry—1961," N.F.A. executive secretary Charles Sheehan; "Foundry Material Handling Costs," R. E. Hayward, Draper Corp.; "Core Cost Control," G. H. Ebbeling, Whitin Machine Works; "Quality Control in the Foundry," C. Wilson, Joy Mfg. Co.

Ferrous sessions include: "The Ductile Iron Process," David Matter, Ohio Ferro-Alloys Corp.; "Gating and Risering Gray Iron," R. Meader, Whitin Machine Works; "Cupolas," A. C. Buesing, Brown Metals, Inc.; "Cost Control in the

Find out for yourself...

why **STEVENS**
sells more
LIQUID PARTING
than anyone else
in the world!

Just fill out the coupon
below for a free test sample.

frederic b. **STEVENS,** inc.
DETROIT 16, MICH.

Frederic B. Stevens, Inc.
1800 — 18th Street
Detroit 16, Michigan

Please rush me a free test sample of Stevens Liquid Parting!

NAME _____ TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ ZONE _____ STATE _____

Circle No. 162, Pages 145-146

Cleaningroom," C. W. Mooney, Link Belt Co., Olney Foundry.

Non-ferrous sessions include: "Selection of Copper-Base Alloys for Pressure Tight Castings," Robert Rosenberg, Nitron Research & Development Corp.; "Light Section Tin-Bronze Castings," Charles Ward, American Radiator & Standard Sanitary Corp.; "Heavy Section Tin-Bronze Castings," Bernie Ames, Columbian Bronze Co.; "Production of Pressure Tight Aluminum Castings," Prof. M. C. Flemings, Massachusetts Institute of Technology.

Purdue's Conference Looks into Future

A look at the future, foreign developments, and metalcasting fundamentals, will be presented at the Purdue Metals Castings Conference to be held Oct. 26, 27 at Purdue University, Lafayette, Ind. The conference is sponsored by the School of Metallurgical Engineering and the Division of Adult Education of Purdue University in cooperation with the AFS Michiana and Central Indiana Chapters.

Howard B. Vorhees, manufacturers' agent, Mishawaka, Ind., is acting general chairman. James C. Maggart, Sibley Machine & Foundry Corp., South Bend, Ind., is program chairman, and Joseph B. Essex, Golden Foundry, Columbus, Ind., is assistant program chairman.

Registration will begin at 8:45 Central Daylight Time in the East Foyer of Memorial Hall.

The program will begin at 9:15 with a showing of "Toshiba in Progress," showing the manufacturing facilities of a Japanese electrical manufacturer. This will be followed by a welcome from John W. Hicks, executive assistant to the president, Purdue University, with a response by AFS Regional Vice-President T. T. Lloyd, Albion Malleable Iron Co., Albion, Mich. Two sessions will be held. "Future of the Foundry Industry," B. L. Simpson, National Engineering Co., Chicago, and "What Is a Foundryman," AFS National Director Carl Schopp, Link-Belt Co., Indianapolis.

Concurrent non-ferrous, iron, and steel sessions will be held in the afternoon.

NON-FERROUS—"An Optimum Method for Every Production System," D. L. La Velle, American Smelting & Refining Co., South Plainfield, N. J. "Effect of

At Wagner Castings Co....

25% savings in shipping labor with Wirebound Pallet Boxes

Bulk handling speeds weighing and shipping of castings

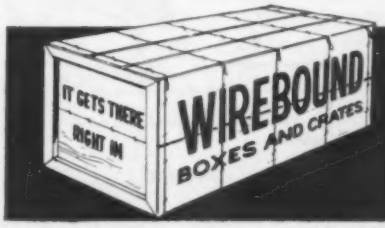
Savings of 25% to 30% have been realized by switching from bags and returnable wood pallet boxes to non-returnable Wirebounds at Wagner Castings Co., Decatur, Ill.

The time required to fill and tie bags, and the cost of returning wood pallet boxes have been eliminated. Even with their 1400-pound loads, these Wirebound pallet boxes stack safely three and four high on the shipping dock, conserving valuable space and speeding shipping operations.

Wagner's customers realize savings, too: handling is minimized—there are no bags to open, no boxes to return. Contents of the Wirebound pallet boxes are accessible for quick identification and for receiving inspection.

At Wagner, Wirebound pallet boxes loaded with malleable iron castings weigh in at about 1400 lbs.

You can realize similar savings by using Wirebound pallet boxes in your manufacturing, assembly and shipping operations. *Contact Wirebound box manufacturers for full information or write to the address below.*



WIREBOUND BOX
MANUFACTURERS ASSOCIATION INC.
222 W. Adams Street, Room 1495
Chicago 6, Illinois

1094

Circle No. 163, Pages 145-146

Design on Making of Non-Ferrous Castings," W. M. Ball, Jr., R. Lavin & Sons, Inc., Chicago.

IRON—"Foundry Engineering in Europe," Louis Pedicini, Lester B. Knight & Associates, Chicago. "Perspectives in Ductile Iron," David Matter, Ohio Ferro-Alloys Corp., Canton, Ohio.

STEEL—"Core Economy," H. G. Robertson, American Steel Foundries, Alliance, Ohio. "Economics in Arcair," Dale Hall, Oklahoma Steel Castings Co., Tulsa, Okla.

A dinner will be held at 6:00 p.m. in the Purdue Memorial Union. The speaker will be Richard F. Mills of Indianapolis.

Technical sessions will be held Friday morning with adjournment scheduled for 12:30 p.m. Speakers and their subjects include "Quality Control and Marketing," T. E. Barlow, Eastern Clay Products Dept., International Minerals & Chemical Co., Skokie, Ill.; "Dollars in Sand," C. A. Sanders, American Colloid Co., Skokie, Ill.; and "Furfural Applications," Wayne Buel, Aristo Corp., Detroit.

Kaiser Dedicates Center

A new technical center was dedicated at Mexico, Mo., by Kaiser Refractories & Chemicals Div., Kaiser Aluminum & Chemical Corp. The laboratory houses research, development, and raw materials personnel.

Within its 17,300 square feet are office space, a testing furnace building, and a general laboratory buildings. It is equipped to develop or improve fireclay, silica and alumina refractory brick, and specialties and to process raw materials required in these products.

R. D. Wood Consolidation

A consolidation of the manufacturing company, Florence Pipe Foundry & Machine Co., with the sales and business subsidiary, R. D. Wood Co., has resulted in discontinuing the use of the name Florence Pipe Foundry & Machine Co. The R. D. Wood office in Philadelphia has been moved to the Florence, N. J. location. All business operations are now conducted from that address as R. D. Wood Co.

Apprentice Contest Competition Opens

Competition is now open in the annual AFS Robert E. Kennedy Memorial Apprentice Contest. National recognition and cash prizes await the first three winners in each of five divisions.

The contest fosters patternmaking and molding competition. Patternmaking covers both wood and metal, while molding includes steel, gray iron, and non-ferrous.

There are three ways of entering the event which closes March 26—through local chapter contests, inter-plant contests, or by individual plants. Inter-plant and individual plants must clear through local chapter contests. In cases where no chapter competition is held, entries may be made directly in the national.

Rules are the same for all competition. Any apprentice, learner, or trainee who has not had more than five years patternmaking experience or not more than four years molding experience is eligible. AFS membership is not required of either the apprentice or his company.

Chapters and plants intending to hold elimination contests must furnish the AFS Central Office with the name of one person as the official contact for all correspondence concerning the contest. Prior to the actual receipt of entries for judging, all contest activities and correspondence should be addressed only to the AFS Education Director, Golf & Wolf Roads, Des Plaines, Ill.

T&RI Spotlights Cutting Costs in Cleaning Room

A new AFS Training & Research Institute course, "Cleaning Room Operations," will be held Nov. 1-3 at the LaSalle Hotel, Chicago. Emphasis is on techniques and methods for cutting costs.

Industry leaders will discuss shakeout and rough cleaning, sawing operations, air hand tools, surface grinding, grinding operations, welding and cutting, and cleaning room safety programs.

"Top management and foundry supervision should be vitally interested in this program," said T&RI

PERMANENT MARKINGS END MIX-UPS!

USE Markal Paintstik MARKERS®

FOR
HEAT TREATING—ANNEALING—WELDING
ACID—ALKALI—CORROSIVE CONDITIONS
GREASY, HEAVILY OILED SURFACES
LUMBER—CERAMICS—GLASS
RUBBER—CLOTH—PLASTICS

PERMANENT • FADE-PROOF WEATHERPROOF

Cold Marking down to —50°F. Hot Marking up to 2400°F.
Send today for literature and test samples.
State exact marking conditions.

The Mark of Quality . . . Markal

Markal COMPANY 3093 W. Carroll Avenue • Chicago 12, Illinois

Circle No. 164, Pages 145-146

Training Supervisor R. E. Betterley. "The cleaning room offers unlimited opportunities for substantial cost reduction," he emphasized. The fee is $60, including daily luncheons and all instructional materials.

Other courses remaining in the T&RI schedule include:

Oct. 2-4—Metallurgy of Gray Iron, Chicago, Fee $60. Features metallurgy of gray iron as applied to foundry production and castings application. Solidification, graphitization, chilling tendencies, innoculation, carbon equivalent, heat treatment, effect on superheat and effect on alloys are discussed in detail.

Oct. 16-18, Sand Control and Technology, Detroit, Fee $60. This course was originally scheduled for Oct. 18-20. Included in course are mold wall movement, hot deformation, creep deformation, mold atmosphere, heat transfer, mechanical properties and metal penetration.

Dec. 4-6, Production Scheduling and Control, Chicago, Fee $60. Definitions and analyses of fundamental production problems are presented. Gives a basic understanding and application of production criteria for effective and economical utilization of equipment, materials and manpower in the production of ferrous and non-ferrous castings.

Course Addition

A special course, "New Core Techniques," has been added to the T&RI schedule. It will be held Nov. 15-17 at the Read House, Chattanooga, Tenn. The Tennessee chapter is co-sponsor with T&RI. Included in the program are the hot box and no-bake furan processes, core box design and equipment, the CO_2 process, and shell cores.

Oremet Uses Centrifugal Strip Rolling Method

Experimental production of tungsten-alloy strip from centrifugally cast material has been started by Oregon Metallurgical Corp., Albany, Ore.

The centrifugally cast material is directly rollable to sheet or strip without prior forging breakdown or extrusion. The material is rollable at much lower temperatures than expected. A 98 per cent tungsten-2 per cent molybdenum alloy was rolled at 1832 F. from an as-cast thickness of 0.64 in. to a finish thickness of 0.035 in. without the benefit of an intermediate annual or recrystallization.

It is believed that the ability to direct roll at this temperature without prior breakdown is due to the fine grain size of the cast material as compared to more conventional arc-cast ingots. In centrifugal castings the rapid solidification against a graphite mold results in equiaxed grains of approximately one-fifth the size of grains in arc-cast ingot.

Is Your Plant Prepared For Emergency Program?

Are you ready for an enemy attack? Emergency plans established by the government are designed to insure survival, rehabilitation, reconstruction, and counter attack, and foundrymen are urged to participate in them.

Harry Blumenthal, Harry Blumenthal Co., Minneapolis, former chairman of the AFS Twin City Chapter, is chairman of the Upper-Midwest Reservist Association, an information organization of Execu-

THE NEW
POWERMET
PRESS
FOR THE MOST RAPID MOUNTING OF METALLURGICAL SAMPLES

- PUSH BUTTON CONTROLLED
- POWER OPERATED
- SELF CONTAINED HYDRAULIC SYSTEM
- CONTROLLED MOLDING PRESSURE
- USE PREMOLDS OR POWDER
- BAKELITE OR TRANSOPTIC MOUNTS
- PRODUCES 1", 1¼", or 1½" MOUNTS
- BAYONET TYPE MOLDS
- THERMOSTATICALLY CONTROLLED HEATERS
- QUALITY COMPONENTS USED
- CONFORMS TO J.I.C. STANDARDS

Buehler Ltd.
METALLURGICAL APPARATUS
2120 GREENWOOD ST., EVANSTON, ILLINOIS, U.S.A.

Circle No. 185, Pages 145-146

tive Reservists, which provides liaison and communication between reservists and other emergency agencies. He urges foundrymen to contact the office of Civil Defense and the nearest office of the U. S. Dept. of Commerce for information concerning emergency plans.

Other Societies

Gray Iron Founders' Annual Meeting Set for Oct. 18-20

Members of the Gray Iron Founders' Society will hold their 33rd annual meeting at the Royal York Hotel, Toronto, Ontario, Canada, Oct. 18-20.

Technical sessions start Thursday, Oct. 19. Highlights on opening day include: "Straight Line to Production," first showing of the new G.I.F.S. movie; "The Business and Political Climate We Live In," H. P. Steele, General Electric Co.; presentation of 1961 Design Contest Awards; "Progress Through Research," A. M. Slichter, Pelton Steel Castings Co.; "What British Cast Iron Research Is and How It Works," Henton Morrogh, Director.

Friday highlights include: "Casting Design and Analysis" and "Cost Saving Design Shortcuts," first showing of G.I.F.S. films; "Operation Vitalization," James Crowley, Pioneer Foundry Co.; "Operation Crossroads," R. W. Hale, Metals and Minerals Economics, and H. W. Lownie, Process Metallurgy Research, Battelle Memorial Institute; presentation of 1961 citations and awards; "Cave Man to Space Man," J. Lewis Powell, author; "Cracker Barrel" sessions on technical subjects, marketing and ductile iron.

Gray Iron Founders' Society will conduct a technical and economic survey of current and future uses for gray and ductile iron castings. Funds have been made available by several producers of merchant pig iron and the program will be conducted under their auspices. G.I.F.S. has contracted with Battelle Memorial Institute to conduct the first fact-finding stage of this four year overall, industry sponsored program to pinpoint both problems and opportunities for the country's 1950 gray iron foundries.

Gray Iron Founders' Society has introduced a new concept in safety contests. The award recognizes the efforts of a firm in setting up an organization within the plant to combat accidents. The new idea "rectifies to a large extent the hardship placed upon the small plant in competing with larger units strictly on a basis of a frequency or severity accident rate where the man-hour exposure factor is so important."

S.F.S.A. Schedules Meetings

For the fifth consecutive year, Steel Founders' Society of America will conduct product and market development regional conferences for salesmen and related personnel in the steel foundry industry.

The first meeting will be held in New Orleans, Sept. 14 and will be followed by sessions in Los Angeles, Oct. 2; New York, Oct. 19; Chicago, Oct. 20; and northwest (locations to be selected later) Nov. 2.

Fulton Acquires Dollin Corp.

Fulton Industries, Inc., Atlanta, Ga., has acquired the business and operating assets of Dollin Corp., Irvington, N. J., producer of aluminum and zinc die castings. The firm will operate as a division of Precision Castings Co., one of Fulton's six operating divisions. Plants are located in Cleveland and Fayetteville, N. Y.

National Lead Adds Plant

National Lead Co. is now in production at its new die casting plant at Boulogne, Argentina, a suburb of Buenos Aires. The plant, operated by National Lead's new subsidiary Doehler Argentina S. A., manufactures die castings and die cast component parts. National Lead has seven plants in the United States, two in Canada, one in Brazil, one in England and the Argentina operation.

Vanadium Launches Promotion

Under the slogan "Service Comes First," Vanadium Corp. of America has launched a new, industry-wide promotion based on customer service. Through advertisements in trade publications, publicity releases, direct mail, posters, and other means, the campaign is gauged to stress the concept of customer service in the ferroalloys industry, its role, its functions, and its value.

ACCURACY + PORTABILITY + ECONOMY
precision measurements
Take it anywhere
Cuts costs
THE KING PORTABLE BRINELL HARDNESS TESTER
DELIVERS ALL THREE FOR UNLIMITED USES!
Precise quality control — the most important function of any hardness test, is one of the many reasons users depend on the King Portable! Together with the King Brinell Scope, the King Portable provides quick readings on almost any size or shape of metal in practically any location!
Economical too, because one test head can be used in many inexpensive adapters.
Get complete information now by writing for literature, prices and a demonstration.
KING TESTER CORP.
446 N. 13TH STREET
PHILADELPHIA 23, PA.
Known the world over for accuracy and dependability • Representatives in principal cities
Certain areas open for representatives
Circle No. 178, Pages 145-146

Metalcasters Must Sharpen Sales Efforts

Modern marketing know-how must be the next big step for all metalcasters. They must, *as an industry*, acquire and use these skills (long applied by competitors). If they don't, other metalworking products and plastics will continue to compete effectively.

In other words, to survive today's competitive rigors, metalcasters must know how to create markets and to serve them profitably. Developing quality castings is not enough.

This was the firm consensus coming from the Foundry Marketing Conference. Held last month in Cleveland, under the sponsorship of International Minerals and Chemical Corp., and Hickman, Williams & Co., it drew a large and enthusiastic group of metalcasters.

Quality control as a key to markets and profits again sparked strong comment, pro and con. Here the focus was on the ability of metalcasters to meet the quality requirements of end users.

There was strong reaction to "castings have the worst quality record of any fabrications purchased by the Cummins Engine Co." But there was also a feeling that customers *must* be pleased or castings will be replaced by competing products.

Also revealed at the marketing conference, according to questions and comments, was the great need for *complete* marketing know-how by metalcasters. It was stressed that good castings are not enough for profitable operation today.

Keynoting this was A. E. Cascino, vice president, marketing, International Minerals & Chemical Corp.

Cascino pointed out that today the customer is king. He is an expert in castings. Metalcasters must identify his needs, make them apparent to him, and customize their products to his needs. They must also know his business.

Audience reaction to this emphasis was good. But questions and comments revealed a wide gap between metalcaster thinking and metalcaster action where the marketing of castings is concerned.

1. **Everyone is part of marketing**—from the top executive to the janitor, every employee must become customer conscious to assure survival. This was the keynote of the second Foundry Marketing Conference held in Cleveland. Designed to advance metalcasting marketing, the meeting was co-sponsored by International Minerals & Chemical Corp. and Hickman, Williams Co. Left to right are John H. Tressler, Vice President, Hickman, Williams and Co.; Norman Dunbeck, Vice President, International Minerals and Chemical Co.; and J. M. Stewart, Vice President, Hickman, Williams and Co., going over last minute details. Over 100 foundrymen from Ohio, Pennsylvania, New York and West Virginia took time out to absorb marketing fundamentals, participate in discussions and fire sharp questions at a panel of experts.

2. Reach the designers—It is imperative that the casting salesman get past purchasing to engineering . . . reach the young engineers who are deciding how a part is to be fabricated and are hungry for information about metalcasting capabilities . . . Casting salesmen should become active in their customer's technical societies where they can participate in programs and meet the design engineers at a personal level—John B. Caine, Foundry Industry Consultant.

3. Know your end users—Deliberate pains must be taken to determine your customer's wants, needs, opinions, reactions . . . In addition to knowing how your customer thinks and acts, be intimately acquainted with his business . . . When you take this broad perspective to your customer's business, you can then assume the enviable role of becoming your customer's personal confidant—Anthony E. Cascino, Vice President, Marketing, International Minerals & Chemical Corp.

4. Stop Sobbing, Start Selling—Salesmen spend far too much of their time policing their accounts rather than developing new business. This is financially unsound, and gives the salesman a ready made excuse for failure to produce . . . The most important and prime fiscal responsibility of sales is proper pricing of the company's products—James W. Hallock, Vice President and Director of Sales, Albion Malleable Iron Co.

5. Control quality, rejects costly—We will lose $361,000 in cost of machining defective castings in 1961 if the present trend continues . . . Add to this the cost of handling and shipping plus the internal scrap cost at the foundry . . . You can buy a lot of quality control protection for a fraction of your scrap costs . . . A definite action program is needed by many foundries to establish the proper responsibility for quality control capability and achieve a healthy supplier-purchaser relationship—Harry S. Kindle, Jr., Manager, Quality Control, Cummins Engine Co.

AFS CHAPTER NEWS

CENTRAL OHIO—Participating in the board of directors meeting are: R. Scardina; R. Gast; J. E. Haller, vice-chairman; G. B. Greenwood, treasurer; J. Dustheimer, E. Kotzin, N. Wukovich, R. E. Moone, secretary; N. V. Stapf, chairman.—by Russell Marande

PITTSBURGH—Picnic entertainment committee; seated, R. V. McKim, Lava Crucible Refractories Co., W. C. Hillman, Jr., Pittsburgh Coke & Chemical Co.; R. F. Maloney, Jr., Kerchner-Marshall & Co. Standing, George Cruickshank and committee chairman C. D. Ziel, Roessing Bronze Co.—by Walter Napp

SOUTHERN CALIFORNIA—New Chapter Chairman A. J. Tuzzilino, Overton Foundry Co., South Gate, right, receives the chapter gavel from outgoing chairman Charles Weisgerber, Alloy Steel & Metals Co., Los Angeles.—by R. E. Gooding

PITTSBURGH—For the second consecutive year Doug Beath, Foseco, Inc., won the Pennsylvania Glass Sand Co. trophy for low gross golf score. Award is being made by D. G. Sloan.—by Walter Napp

Chapters May Sponsor Courses with T&RI

Chapters intending to participate in the T&RI 1962 program of regional courses are advised to contact AFS Headquarters this month. The new schedule is now being planned.

Since its inception in 1957, seven chapters have conducted 14 courses. The Ontario Chapter has sponsored a course each of the four years.

Local Chapters can utilize the T&RI services and plan a local course by establishing five factors. They are: (1) The name and type of each course to be held, (2) Length of course, (3) Where and when the course is to be given, (4) Willingness of the local chapter to adequately sponsor a course, and (5) The appointment of a local liaison officer for chapter contact.

T&RI will handle all course details including instructors, hotel facilities, instructional materials, meal functions, and promotional literature. Local chapters have the responsibility of publicizing the program at chapter meetings.

Regional courses can be planned on many subjects including: Cupola Melting of Iron, Gating and Risering, Gray Iron Metallurgy, Ferrous Metallurgy, Non-Ferrous Metallurgy, Sand Control and Technology, Preventive Maintenance, Melting of Light and Copper-Base Alloys, Shell Molds and Cores, Core Practices, and Ductile Iron Production. Other courses will also be considered.

All inquiries for additional information regarding regional T&RI courses should be directed to AFS Training & Research Institute, Golf & Wolf Roads, Des Plaines, Ill.

PHILADELPHIA—Former Chapter Chairman John M. Robb (left), Pennsylvania Foundry Supply & Sand Co., Philadelphia, presents lifetime AFS membership card to George Bradshaw, who recently retired after 35 years in the foundry industry.—by Leo Houser and E. C. Klank

AFS Chapter Meetings

OCTOBER 10-NOVEMBER 10

Birmingham District . . Nov. 10 . . University of Alabama, Tuscaloosa, Alabama.

Canton District . . Nov. 2 . . Town and Country Restaurant, Canton, Ohio . . Wayne H. Buell, Aristo Corporation, **"Furan and Single Stage Phenolics."**

Central Illinois . . Nov. 6 . . Legion Hall, Peoria, Ill. . . . **University of Illinois Student Guest Night.**

Central Indiana . . Nov. 6 . . Athenaeum Club, Indianapolis . . . Frank B. Downey, Pneumatic Tool Div., Ingersoll-Rand Co., **"Improving Operations and Maintenance of Air Tools."**

Central Michigan . . Oct. 18 . . Hart Hotel, Battle Creek, Mich.

Central New York . . Oct. 13 . . Woodruff Hotel, Watertown, N. Y. . . Roger B. Sinclair, Roger B. Sinclair Associates, **"Casting Costs."**

Chicago . . Nov. 6 . . Chicago Bar Association, Chicago.

Connecticut . . Oct. 19 . . American Standard Controls Corp., Stratford, Conn. . . **Plant Visitation.**

Corn Belt . . Oct. 20 . . Beatrice, Nebraska . . Joseph A. Gitzen, Delta Oil Products Co., **"New Core Binders."**

Metropolitan . . Nov. 6 . . Military Park Hotel, Newark, N. J. . . R. J. Mulligan, Archer - Daniels - Midland Co., **"Furan Technology and Its Impact in the Foundry."**

Mid-South . . Oct. 13 . . Claridge Hotel, Memphis, Tenn. . . A. Lesley Gardner, Pangborn Corp., **"Cleaning Rooms of Tomorrow." . . Nov. 10 . .** Ray Olson, Southern Precision Pattern Works, **"Shell Molding & Cores."**

Mo-Kan . . Oct. 19 . . Kansas City, Kansas . . Joseph A. Gitzen, Delta Oil Products Co., **"Application and Properties of Old and New Core Binders."**

New England . . Nov. 8 . . University Club, Boston.

Northeastern Ohio . . Oct. 12 . . Manger Hotel, Cleveland . . Prof. Richard W. Heine, University of Wisconsin, **"Modern Sand Composition, Mixing and Ramming Processes."**

Northern Illinois & Southern Wisconsin . . Oct. 10 . . Beloit Iron Works, Beloit, Wis. **Plant Visitation.**

Northwestern Pennsylvania . . Oct. 23 . . Amity Inn, Erie, Pa. . . Ralph Clark, John Vogt, Victor Popp, Union Carbide Metals Co., Round Table: **"Use of Alloys, Gray and Ductile Iron, Non-Ferrous, Steel."**

Ontario . . Oct. 13 . . Seaway Hotel, Toronto . . R. J. Hart, Canada Wire & Cable Co., Ltd., **"Good Supervision Pays Off."**

Oregon . . Oct. 18 . . Heathman Hotel, Portland, Oregon . . H. I. Montgomery, State of Oregon Industrial Accident Commission, **"Safety."**

Philadelphia . . Oct. 13 . . Engineers' Club, Philadelphia . . George F. Sullivan, Editor, Iron Age, **"Inside the Soviet Steel Industry."**

Piedmont . . Nov. 3 . . Spartanburg, N. C.

Pittsburgh . . Oct. 16 . . Hotel Webster Hall, Pittsburgh, Pa.

Quad City . . Oct. 16 . . Le Claire Hotel, Moline, Ill.

Saginaw Valley . . Nov. 2 . . Bavarian Inn, Frankenmuth, Mich.

St. Louis District . . Oct. 12 . . Edmonds Restaurant, St. Louis, Mo. . . Prof. Owen D. Miller, Washington University, **"Work Sampling in the Foundry."**

Southern California . . Oct. 13 . . Rodger Young Auditorium, Los Angeles.

Texas . . Oct. 20 . . Western Hills Inn, Fort Worth, Texas.

Texas—San Antonio Section . . Oct. 23 . . Alamo Iron Works, San Antonio, Texas.

Timberline . . Oct. 18 . . Engineers' Club, Denver, Colo. . . Joseph A. Gitzen, Delta Oil Products Co., **"Application and Properties of Old and New Core Binders."**

Tri-State . . Oct. 13 . . Joplin, Mo. . . Nov. 10 . . Blackwell, Okla.

Twin City . . Oct. 10 . . Jax Cafe, Minneapolis . . Ralph Betterley, Educational Director, AFS, **"Communication Problems in the Foundry."**

Wisconsin . . Oct. 13 . . Schroeder Hotel, Milwaukee . . L. J. Pedicini, Lester B. Knight & Assoc., Inc. **"Foundry Engineering in Europe."**

Future Meetings and Exhibits

Oct. 5-6 . . Ohio Regional Conference. Netherland Hilton Hotel, Cincinnati.

Oct. 13-14 . . New England Foundry Conference, Massachusetts Institute of Technology, Cambridge, Mass.

Oct. 16-18 . . The Magnesium Association, Annual Convention, Belmont Plaza Hotel, New York.

Oct. 16-20 . . National Safety Council. 1961 National Safety Congress, Conrad Hilton Hotel, Chicago.

Oct. 16-21 . . National Industrial Sand Association, Semi-Annual Meeting. The Greenbrier, White Sulphur Springs, W. Va.

Oct. 17-Nov. 9 . . Iron & Steel Institute, American Institute of Mining, Metallurgical, and Petroleum Engineers, Special Joint Meetings in Various Cities of the U. S. and Canada.

Oct. 18-20 . . Gray Iron Founders' Society. Annual Meeting, Royal York Hotel, Toronto, Ont., Canada.

Oct. 19-20 . . Michigan Regional Foundry Conference. Michigan State University, East Lansing, Mich.

Oct. 19-21 . . Foundry Equipment Manufacturers Assn., Annual Meeting, The Greenbrier, White Sulphur Springs, W. Va.

Oct. 23-27 . . American Society for Metals, Detroit Metal Show (43rd National Metal Congress and Exposition), Cobo Hall, Detroit, Mich.

Oct. 26-27 . . Purdue Metals Castings Conference, Purdue University, Lafayette, Ind.

Oct. 26-27 . . 2nd Biennial North Central States Apprenticeship Conference, Conrad Hilton Hotel, Chicago.

Nov. 13-14 . . Association of Technique De Fonderie. 34th Foundry Congress, Paris, France.

Nov. 13-15 . . Steel Founders' Society of America, Technical & Operating Conference. Pick Carter Hotel, Cleveland.

Nov. 15-17 . . National Foundry Association, Annual Meeting. Savoy-Hilton Hotel, New York.

Dec. 6-8 . . American Institute of Mining, Metallurgical and Petroleum Engineers, Electric Furnace Conference, Penn-Sheraton Hotel, Pittsburgh, Pa.

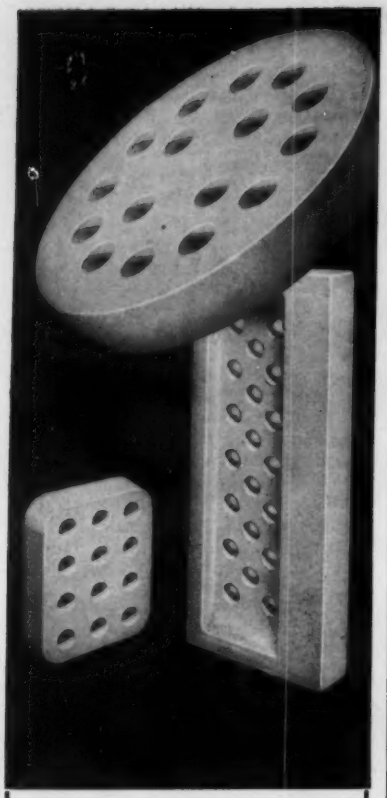
Feb. 8-9 . . Wisconsin Regional Foundry Conference, Hotel Schroeder, Milwaukee.

Feb. 15-16 . . Southeastern Regional Foundry Conference, Thomas Jefferson Hotel, Birmingham, Ala.

March 12-13 . . Steel Founders' Society of America, annual meeting, Drake Hotel, Chicago.

March 15-16 . . Texas Regional Foundry Conference, Menger Hotel, San Antonio, Texas.

May 7-11, 1962 . . AFS 66th Annual Castings Congress and Exposition, In conjunction with The 29th International Foundry Congress . . Cobo Hall . . Detroit.



Louthan strainer cores cut foundry costs

You minimize casting problems, get cleaner castings when you use Louthan *refractory* strainer cores. Now available in more sizes and shapes—and for steel, iron, brass and bronze castings. All provide an accurate choke for positive control of metal flow, eliminate slag and oxide inclusions.

Write for Free Gating and Risering Refractory Folder. Complete file of specifications on all Louthan products.

LOUTHAN

EAST LIVERPOOL, OHIO

A UNIT OF FERRO CORPORATION

Refractories Division

Circle No. 187, Pages 145-146

Metalcasters in the News . . .

Albert E. Rhoads . . . president and chief executive officer of Engineering Castings, Inc., Marshall, Mich., is relinquishing his executive responsibilities in the company management. He remains on the board of directors and continues in a consulting and advisory capacity. **Kenneth W. Rhoads** is now chairman of the board and the chief executive officer. He will also continue as treasurer. **David W. Boyd** is now president and the chief executive officer. K. W. Rhoads is vice-chairman of the AFS Central Michigan Chapter. Boyd is a former AFS Regional Vice-President.

John E. McIntyre . . . is now president of Sibley Machine & Foundry Corp., South Bend, Ind. **William H. Voll** is vice-president in charge of sales, **Philip G. Hahl** is secretary.

Robert G. Patrick . . . has joined C&S Products Co., DeKalb, Ill., as sales manager.

H. E. Martin . . . is chairman and chief executive officer of Metal & Thermit Corp., New York. Replacing him as president is **Charles J. Beasley,** formerly vice-president and secretary. **H. W. Buchanan,** previously a vice-president, is now executive vice-president.

W. F. Joseph . . . named technical director of Rossborough Supply Co., Cleveland. He will be responsible for completing development of several products for non-ferrous foundries and customer service.

J. J. Davis . . . elected as president, ESCO Corp., Portland, Ore. He has been executive vice-president. Other changes: **Newman Ward,** former president, becomes chairman of the board; **C. F. Swigert, Jr.,** becomes honorary board chairman.

Dr. James L. Wyatt . . . appointed as vice-president for program development, Armour Research Foundation of Illinois Institute of Technology, Chicago.

J. E. LeMay . . . named carbon products marketing manager for National Carbon Co., Div. Union Carbide Corp., succeeding **W. C. McCosh,** recently named director of marketing for the company.

G. F. Ritter . . . named service manager, C & S Products Co., DeKalb, Ill. C & S recently moved from Detroit.

David Schiffer . . . in charge of scrap purchasing and **William Hoskin,** production superintendent, have received promotions at the Cleveland operations of Apex Smelting Co. of Chicago. **Erik Windmiller** has been made assistant vice-president with administrative functions in Chicago. **William R. Bayer** has been elected president of the wholly-owned subsidiary, Apex Smelting Co. (California), at Long Beach. He succeeds **Louis Lippa** who continues as president of the parent company. Newly elected assistant vice-presidents of the California subsidiary are **Robert Raisig,** production superintendent, and **John Stobie,** sales manager.

A. M. Randolph Charrington, Jr. . . . appointed eastern representative for Aluminum & Magnesium, Inc., Sandusky, Ohio. He will be responsible for sales throughout the New England and Middle Atlantic states.

Raymond C. Howell . . . named chief works engineer of the American Steel Foundries' Transportation Equipment Div.

Leon F. Corp . . . has retired as assistant manufacturing manager, Central Foundry Div., General Motors Corp. He served Central Foundry Div. for over 35 years, starting in 1926 with Saginaw Malleable Iron Div. (forerunner of Central Foundry Div.).

A. E. Field . . . has become a vice-president of National Castings Co., Cleveland. He will continue as secretary, a position he has held since 1946.

Donald E. Moat . . . is now vice-president-government and foreign relations, Leeds & Northrop Co., Philadelphia. Other changes include: **John F. Quereau,** vice-president and director of marketing;

Advertised Products
October—1961

Page Numbers

ABRASIVES, BLASTING
- **Hickman Williams & Co.** 22
- **Metal Blast, Inc.** 62

ALUMINUM ALLOYS
- **Olin Mathieson Chemical Corp.** .....2nd Cover
- **Apex Smelting Co.** 25
- **American Smelting & Refining Co., Federated Metals Div.** 27
- **Vanadium Corp. of America** 133

ARC CUTTING RODS
- **Speer Carbon Co.** 60

CARBON SAND
- **Humble Oil & Refining Co.** 8

COKE
- **Pittsburgh Coke & Chemical Co.** 31
- **Pickands Mather & Co.** 40
- **Semet-Solvay Div., Allied Chemical Co.** 59
- **DeBardeleben Coal Corp.**...152

CONSULTING SERVICES
- **Lester B. Knight & Associates, Inc.** 129

CONTAINERS, PALLETS & BOXES
- **Wirebound Box Mfrs. Assoc.** 137

CORE BINDERS
- **Archer-Daniels-Midland Co.** 16

CORE SHOOTERS
- **Carver Foundry Products.**. 1

CRUCIBLES
- **American Refractories & Crucible Co.** 20

DEOXIDIZERS
- **Carborundum Corp.** 7

FERRO-ALLOYS
- **Union Carbide Metals Co., Div. Union Carbide Corp.** 19
- **Vanadium Corp. of America** 133

FILM
- **Eastman Kodak Co.** 57

FLASKS AND JACKETS
- **Hines Flask Co.** 32
- **The Adams Co.** 34

FLUXES
- **The Cleveland Flux Co.** 35

FURNACES, ELECTRIC
- **Brown Boveri Corp.** 12

INOCULANTS
- **Ohio Ferro-Alloys Corp.** 2

LADIES
- **Industrial Equipment Co.** ...147

LIQUID PARTING AGENT
- **Frederic B. Stevens, Inc.**....136

MARKING DEVICES
- **Markal Co.** 138

MATERIALS HANDLING EQUIPMENT
- **The Frank G. Hough Co.** 18
- **Syntron Co.** 24
- **Whiting Corp.** 135

(Continued next page)

"One Stop" Service for Metalcasters

On this page you will find an alphabetical reference guide to products, processes, and services offered by advertisers of MODERN CASTINGS. In the same column you will see the names of the advertisers offering the service and the page number of the ads.

This is designed as a "one stop" reference for busy metalcasters in search of important information. Each advertiser has prepared this important material with you in mind. Keeping well-informed is essential in today's highly competitive market.

Another important step to increase your "one stop" reading is the merging of "New Products and Processes" and "For the Asking" into a single, easy-to-read section entitled "Metalcasting Products and Processes."

Use the handy Reader Service Card below to build a valuable reference file of new products, processes, and techniques. The manufacturers who participate in this section are eager to send data to any qualified reader of MODERN CASTINGS.

OCTOBER 1961—1

Valid through Dec. 1961

NEW EQUIPMENT AND LITERATURE										ADVERTISED PRODUCTS							
1	13	25	37	49	61	73	85	97	109	121	133	145	157	169	181	193	205
2	14	26	38	50	62	74	86	98	110	122	134	146	158	170	182	194	206
3	15	27	39	51	63	75	87	99	111	123	135	147	159	171	183	195	207
4	16	28	40	52	64	76	88	100	112	124	136	148	160	172	184	196	208
5	17	29	41	53	65	77	89	101	113	125	137	149	161	173	185	197	209
6	18	30	42	54	66	78	90	102	114	126	138	150	162	174	186	198	210
7	19	31	43	55	67	79	91	103	115	127	139	151	163	175	187	199	211
8	20	32	44	56	68	80	92	104	116	128	140	152	164	176	188	200	212
9	21	33	45	57	69	81	93	105	117	129	141	153	165	177	189	201	213
10	22	34	46	58	70	82	94	106	118	130	142	154	166	178	190	202	214
11	23	35	47	59	71	83	95	107	119	131	143	155	167	179	191	203	215
12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216

Please Print and Fill Out Completely to Validate Your Requests

Name

Position

Company

Address

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 83, Sec. 34.9, P. L. & R.
DES PLAINES, ILL.

Reader Service Dept.
MODERN CASTINGS
Golf and Wolf Rds.
Des Plaines, Ill.

"One Stop" Service for Metalcasters

On this page you will find an alphabetical reference guide to products, processes, and services offered by advertisers of MODERN CASTINGS. In the same column you will see the names of the advertisers offering the service and the page number of the ads.

This is designed as a "one stop" reference for busy metalcasters in search of important information. Each advertiser has prepared this important material with you in mind. Keeping well-informed is essential in today's highly competitive market.

Another important step to increase your "one stop" reading is the merging of "New Products and Processes" and "For the Asking" into a single, easy-to-read section entitled "Metalcasting Products and Processes."

Use the handy Reader Service Card below to build a valuable reference file of new products, processes, and techniques. The manufacturers who participate in this section are eager to send data to any qualified reader of MODERN CASTINGS.

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 83, Sec. 34.9, P. L. & R.
DES PLAINES, ILL.

Reader Service Dept.
MODERN CASTINGS
Golf and Wolf Rds.
Des Plaines, Ill.

OCTOBER 1961—2

Valid through Dec. 1961

NEW EQUIPMENT AND LITERATURE

1	13	25	37	49	61	73	85	97	109
2	14	26	38	50	62	74	86	98	110
3	15	27	39	51	63	75	87	99	111
4	16	28	40	52	64	76	88	100	112
5	17	29	41	53	65	77	89	101	113
6	18	30	42	54	66	78	90	102	114
7	19	31	43	55	67	79	91	103	115
8	20	32	44	56	68	80	92	104	116
9	21	33	45	57	69	81	93	105	117
10	22	34	46	58	70	82	94	106	118
11	23	35	47	59	71	83	95	107	119
12	24	36	48	60	72	84	96	108	120

ADVERTISED PRODUCTS

121	133	145	157	169	181	193	205
122	134	146	158	170	182	194	206
123	135	147	159	171	183	195	207
124	136	148	160	172	184	196	208
125	137	149	161	173	185	197	209
126	138	150	162	174	186	198	210
127	139	151	163	175	187	199	211
128	140	152	164	176	188	200	212
129	141	153	165	177	189	201	213
130	142	154	166	178	190	202	214
131	143	155	167	179	191	203	215
132	144	156	168	180	192	204	216

Please Print and Fill Out Completely to Validate Your Requests

Name

Position

Company

Address

Advertised Products October—1961 (cont.)

Page Numbers

METALLURGICAL EQUIPMENT
Buehler, Ltd. 139
MOLDING MACHINES
British Moulding Machine Co., Ltd. 63
MOLYBDENUM ALLOYS
Molybdenum Corp. of America ..... 3rd Cover
NICKEL ALLOYS
The International Nickel Co., Inc. 4, 15
PERMANENT MOLDING EQUIPMENT
Permanent Mold Die Co. ... 61
PIG IRON
The Hanna Furnace Corp., Div. National Steel Corp. 28, 29
Alan Wood Steel Co. 38
Vanadium Corp. of America 133
RARE EARTH ALLOYS
Vitro Chemical Co. 26
REFRACTORY STRAINER CORES
Louthan Co., Div. Ferro Corp. 144
SAND BINDERS, BENTONITE
Magnet Cove Barium Corp. 30
SAND BINDERS, RESIN
Reichhold Chemicals, Inc. ..... 4th Cover
SAND CONDITIONING AND HANDLING EQUIPMENT
Beardsley & Piper Div., Pettibone Mulliken Corp. 10, 11
Clearfield Machine Co. 21
National Engineering Co. ... 23
Royer Foundry & Machine Co. 130
SAND TESTING EQUIPMENT
Harry W. Dietert Co. 152
SHELL CORE MOLDING MACHINES
Shalco Div., National Acme Co. 33
SHELL MOLDING SAND
Pennsylvania Glass Sand Corp. 17
SILICA SAND
Wedron Silica Co. 39
TECHNICAL PUBLICATIONS
British Cast Iron Research Association 148
TEMPERATURE MEASURING EQUIPMENT
Pyrometer Instrument Co. 149
L. H. Marshall Co. 151
TESTING EQUIPMENT
King Tester Corp. 140
VANADIUM ALLOYS
Vanadium Corp. of America 133
ZIRCON SAND AND FLOUR
Metal & Thermit Corp. 14
Berkshire Chemicals, Inc. ...150

J. Frederick Schock, local manager at North Wales plant in addition to retaining job as manager of order control division; **William M. Feeley,** manager of plant engineering and services division.

W. M. Kelly . . . appointed manager-technical operations for Union Carbide Metals Co., Div. Union Carbide Corp. He had been assistant technical director-alloys operations since 1959.

Lewis E. Gage . . . appointed to market development staff of American Zinc Institute.

Joseph R. Roberts . . . advanced to newly created position of director of advertising, Aeroquip Corp., Jackson, Mich.

Charles A. Myers . . . advanced from sales manager to position of vice-president in charge of sales at Belle City Malleable Iron Co., and Racine Steel Castings Co., Racine, Wis.

Thomas J. Whitby . . . appointed information scientist-metallurgical in the New Haven, Conn., research services department, Olin Mathieson Chemical Corp.

O. R. Magoteaux . . . joins the research staff of Chas. Taylor Sons Co., Cincinnati, subsidiary of National Lead Co. He was formerly employed by National Lead Co. of Ohio.

J. James Offutt . . . elected executive vice-president, A. P. Green Fire Brick Co., Mexico, Mo., succeeding **L. J. Miller** who retired. Since last September, Offutt has been vice-president and general manager.

John McDermott . . . promoted to works manager, Jersey City manufacturing operations, Joseph Dixon Crucible Co., Jersey City, N. J. **Charles J. Meyer** appointed general superintendent Industrial Div., and **Victor E. Fitzpatrick,** named as manager, Standards Dept.

Bernard H. Regenburg . . . elected president and general manager of the Belle City Malleable Iron Co. and Racine Steel Castings Co., both of Racine, Wis. Regenburg succeeds **R. J. Swartout** as president and **C. S. Anderson** as the company's chief executive officer. Both Swartout and Anderson are retiring from active management of the company, although Anderson remains as chairman of the board. Other changes include: **K. M. Halvorson,** vice-president, manufacturing; **W. R. Young,** vice-president, industrial relations; **H. C. Cunningham,** secretary and controller; **R. D. Leutner,** treasurer and assistant secretary; **E. K. Simonsen,** sales manager.

Fred W. Genger . . . is sales manager of the New York office, National Castings Co. Transportation Products Div. He succeeds **Donald F. Kittredge,** recently appointed assistant vice-president of the company's international division.

Warren A. Zimmer . . . named senior vice-president, Joseph Dixon Crucible Co., Jersey City, N. J.

Clifford Amend . . . appointed as metallurgist, Ajax Magnethermic Corp., Youngstown, Ohio. He will be concerned primarily with heat-treating applications and testing of heat-treating production units.

Britton E. Balzerit . . . is manager, market development, Industrial Div., Corn Products Sales Co.

Charles M. Brown . . . appointed superintendent of the foundry at Dodge Mfg. Corp., Mishawaka, Ind., succeeding **Matthew Goodall, Jr.,** who has retired.

Vernon M. Barber . . . named sales promotion manager for Hills-Mccanna Co., Carpentersville, Ill.

Deaths

Clarence G. Millner . . . 52, president of Progressive Foundries, Inc., Lakeville, N. Y.

Charles F. Amsden . . . supervisor Cadillac Motor Car Co., Div., General Motors Corp., Detroit.

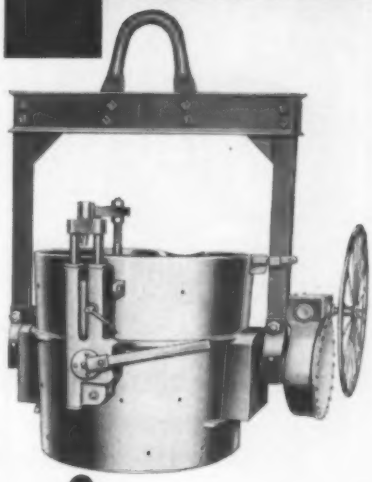
Paul Bechtner . . . 79, board chairman of American Colloid Co., Skokie, Ill.

Perry A. MacArthur . . . for the past 23 years, sales reprsentative of S. Obermayer Co., Chicago.

William L. Garner . . . 72, sales engineer, Exomet, Inc., Conneaut, Ohio. He had served with the company 11 years.

safe

slag-free pouring in large volumes



industrial

TYPE 568 TGT

A BOTTOM-DISCHARGE LADLE in models with capacities from 10,000 to 40,000 lbs. Geared discharge mechanism. Eighteen lever positions are provided for adjusting the operating lever to proper height for safe, easy pouring. Lift column locks at any height. Gear unit operates in continuous oil bath; housing cover bolted at rear for easy maintenance. Engineered overall to save space, promote safety and efficiency.

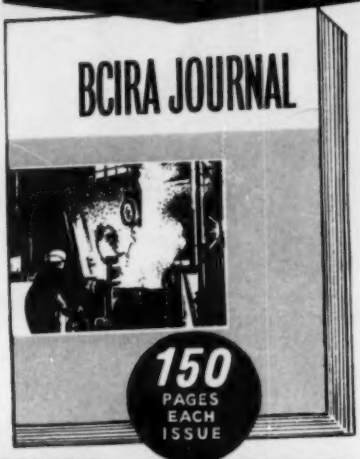
Send your pouring problems to us. Ask for the latest catalog on our complete line of standard and custom pouring and handling equipment.

Industrial EQUIPMENT COMPANY

271 Ohio St., Minster, Ohio

Circle No. 170, Pages 145-146

This book, on your desk, regularly



keeps you up to date on iron casting research

Official publication of **THE BRITISH CAST IRON RESEARCH ASSOCIATION**

Throughout the year, you can have in front of you *complete* reports on the continuous research projects and practical foundry investigations undertaken by the British Cast Iron Research Association. The B.C.R.I.A. Journal also includes abstracts of technical articles and new developments from world wide sources. Each issue runs to 150 pages packed with information. Send your subscription now—or mail the coupon for a free copy of the current issue.

RECENT CONTENTS COVER

- Causes of Shrinkage Defects
- Spectrographic Analysis of Slags
- Production of Dross-free Nodular Iron
- Behaviour of Clay-bonded Sands
- Stress/Strain Properties of Grey Iron
- Hot Box Core Binder Properties
- Chilling Mechanism of Chromium
- Oxygen Injection in the Cupola

One year's subscription, mailed to you alternate months, on publication $20

BCIRA JOURNAL

MAIL THIS COUPON for FREE specimen copy

THE BRITISH CAST IRON RESEARCH ASSOCIATION
Bordesley Hall, Alvechurch, Birmingham, England.

NAME .....
TITLE .....
COMPANY .....
ADDRESS .....
CITY ..... ZONE .....
STATE MC4

Circle No. 188, Pages 145-146

New Metalcasting Equipment and Processes

What's new in foundry methods and equipment? Summaries of the latest news from manufacturers and suppliers are presented below. For more complete information, circle the corresponding number on the free postcard on page 145. Mail it to us; we'll do the rest.

Equipment

Centrifugal casting machine . . . horizontal type, is equipped with gas mold heating for pre-heating molds before initial castings are made. Also has high velocity water cooling for maintaining desired mold temperature during casting. Equipped with pneumatically operated mold spray equipment for spraying lining into permanent molds. Design Engineering & Products Co.

Circle No. 1, Pages 145-146

All-purpose batch mixer . . . can be used for stirring, blending, folding or tumbling and can mix liquids, powders, granular materials, slurries, or pastes. Consists of rotating drum mixer with stationary removable paddle. Kol, Inc.

Circle No. 2, Pages 145-146

Heavy-duty vibrating feeder . . . reportedly is the industry's largest. Positive feed movement conveys materials up to 150 feet per min. Eight-page bulletin gives details and applications. Hewitt-Robins.

Circle No. 3, Pages 145-146

High vacuum vapor pumps . . . are given thorough treatment in 52-page catalog including many charts, graphs, and tables. Consolidated Vacuum Corp.

Circle No. 4, Pages 145-146

Flask rotator . . . features rapid cycling and automatic control and indexing. Nomad Equipment Co.

Circle No. 5, Pages 145-146

Spiroid gear transmission . . . in hand chain hoists are said to speed lifting with lower maintenance costs. Aluminum housing provides light weight. Coffing Hoist Div., Duff-Norton Co.

Circle No. 6, Pages 145-146

High temperature hardness . . . indentor operates under heat conditions up to 3000 F. A specially developed sapphire solidly mounted in a molybdenum shank are basic components. Indentors are manufactured with jewels mounted in a wide variety of shanks for use in all standard testing machines. Laboratory technicians and metallurgists can obtain specific indentors to meet their own laboratory conditions. F. F. Gilmore & Co.

Circle No. 7, Pages 145-146

Electric induction furnaces . . . use a controlled stirring action to produce a homogenized, fine-grained metal of high strength and ductility, according to 12-page bulletin. Reportedly even low-grade scrap can be refined into high-quality common cast iron. Hevi-Duty Electric Co.

Circle No. 8, Pages 145-146

Crane hooks . . . bulletin outlines data on hooks ranging in capacities from five to 200 tons. American Forge & Mfg. Co.

Circle No. 9, Pages 145-146

Reverberatory furnace . . . with improved roof design and construction which cut excessive wear and increase life. U. S. Smelting Furnace Co.

Circle No. 10, Pages 145-146

Compressed air filters . . . can be evaluated through a practical method. Four-page bulletin outlines setup using this testing method. King Engineering Corp.

Circle No. 11, Pages 145-146

Tramp iron magnetic separator . . . available for suspending over conveyors, chutes, or spouts. Unit is self-cleaning and permanently magnetic. Four-page catalog outlines details. Dings Magnetic Separator Co.

Circle No. 12, Pages 145-146

Remote cameras see in furnace . . . with two refrigerated television cameras. Cameras are located 3 feet from radiant heat at 2300 F. One takes picture of charging operation. The other peers through

small opening to show slabs inside slab reheat furnace. Larco, Inc.

Circle No. 13, Pages 145-146

Vacuum furnace . . . 50 pound capacity, induction-heated melting type is designed for research and development work or small-quantity production. Cycle-time has been reduced by increasing the pump-down speed of the vacuum pumping system. F. J. Stokes Corp.

Circle No. 14, Pages 145-146

Plastics materials mixer . . . employs new concept in mixing high and low viscosity materials such as epoxy and sand, polyesters, gypsum cements, and mold making plasters. Mixes up to 70 pounds of material in two to three minutes. Plaster Supply House.

Circle No. 15, Pages 145-146

Side shifter . . . for lift trucks moves forks four inches to either side of the center of truck. Increases handling operations by eliminating time in re-positioning truck. Little Giant Products, Inc.

Circle No. 16, Pages 145-146

Pot-type melting furnace . . . line designed for melting and holding zinc, aluminum, magnesium, lead, and other non-ferrous metals. Can be equipped for gas, oil, or dual fuel operation. J. A. Kozma Co.

Circle No. 17, Pages 145-146

Wire rope conveyors . . . described in 24-page bulletin which covers the entire field. Well illustrated with drawings, photos, and charts. Hewitt-Robins.

Circle No. 18, Pages 145-146

High vacuum valves . . . made of cast stainless steel are the right angle O-ring type. An effective motion seal consisting of two O-rings with a space between which is evacuated by the mechanical pump is employed. F. J. Cooke, Inc.

Circle No. 19, Pages 145-146

Traveling cranes . . . overhead electric type, are discussed in 20-page bulletin. Well illustrated with applications, working features, and specifications. Crane & Hoist Div., Manning, Maxwell & Moore, Inc.

Circle No. 20, Pages 145-146

Physical test instruments . . . general catalog lists complete line in 28-page brochure. Gardner Laboratory, Inc.

Circle No. 21, Pages 145-146

Electric vibrator . . . for use on small bins, chutes and hoppers is designed for continuous or intermittent service. Cleveland Vibrator Co.

Circle No. 22, Pages 145-146

Closed circuit TV . . . can be used for surveillance, quality control, dispatching, security, and observation in hazardous locations. Catalog outlines applications and system specifications. Electronics Div., Fairbanks, Morse & Co.

Circle No. 23, Pages 145-146

Compact drying oven . . . operates from room temperature to 392 F. Inside chamber dimensions are 10x10x12 in. Central Scientific Co.

Circle No. 24, Pages 145-146

Compression and tensile measuring . . . device simultaneously performs both operations. Split dial gives readings of compression and tensile loads and can be used whenever pressure, tensile, or torque loads are to be measured. Accuracy is guaranteed to within plus or minus 1 per cent of full scale reading. W. C. Dillion & Co.

Circle No. 25, Pages 145-146

Analyzer . . . determines nitrogen in refractory materials. Will determine nitrogen in titanium nitride, silicon nitride, bonded silicon carbide, molybdenum metal, boron nitride, chromium nitride, zirconium boride, and aluminum nitride. Laboratory Equipment Co.

Circle No. 26, Pages 145-146

Fire protection cutoff valve . . . can be installed in any position with minimum of space. Stainless steel valve is a bolted-bonnet gate valve held open against two stainless steel springs by a fusible link. At a preselected temperature the link melts allowing springs to snap the valve shut. Valves & Fittings Div., Cooper Alloy Corp.

Circle No. 27, Pages 145-146

Pneumatic temperature transmitter . . . measures up to 1400 F. Twelve-page bulletin illustrates principles and method of installation. Foxboro Co.

Circle No. 28, Pages 145-146

Rotary valve . . . for feeding dry bulk materials or as air seal are described in four-page bulletin. Day Co.

Circle No. 29, Pages 145-146

MEASURE HEAT ACCURATELY with

the improved

PYRO OPTICAL PYROMETER

The only self-contained direct-reading optical pyrometer for quick temperature measurements of molten iron, steel, monel, etc.

Send for catalog No. 85.

the universal

PYRO SURFACE PYROMETER

Rugged, easy to read. Ideal for shell molding, core oven, mold and die surface temperature measurements. Single and double ranges from 0-300°F to 0-1500°F.

Send for catalog No. 168.

PYROMETER INSTRUMENT CO., INC.
BERGENFIELD 10, NEW JERSEY

Circle No. 169, Pages 145-146

Supplies

Ceramic gating components . . . catalog covers all standards including newly developed choke bushing, sweep ells, angle sections, tuyere tubes, and pouring basins in round and rectangular entry types. Universal Clay Products Co.

Circle No. 30, Pages 145-146

Core oil additive . . . cuts baking time by 60 per cent. Furan resin type binder replaces 30 per cent of oil in any conventional sand mix. Can be blown in production cores at high rate. G. E. Smith, Inc.

Circle No. 31, Pages 145-146

High alumina ramming mixes . . . completes line of high alumina mixes. One contains 70 per cent alumina, the other 90 per cent. Kaiser Refractories & Chemicals Div., Kaiser Aluminum & Chemical Corp.

Circle No. 32, Pages 145-146

Sand expansion defects . . . reportedly are controlled by new product which is said to eliminate rat-tails, buckles, and scabs in iron or non-ferrous castings made in synthetically or naturally bonded green sand. It has been used to replace skin-drying and to substitute a green ram-up core for a regular black sand core, thus eliminating baking. Used as a direct addition to green heap or green facing sands. Whitehead Brothers Co.

Circle No. 33, Pages 145-146

Alloys numbering system . . . for company's products replaces previous designations. Also includes nominal chemical compositions. Huntington Alloy Products Div., International Nickel Co.

Circle No. 34, Pages 145-146

Alumina silicate . . . aids in controlling metal penetration. New material will enable gray and malleable foundries to reduce veining faults caused by surface expansion cracks. Seven-page report contains description and applications. Archer-Daniels-Midland Co., Federal Foundry Supply Div.

Circle No. 35, Pages 145-146

Radiation monitoring services . . . are outlined in eight-page brochure. Includes complete film badge service, types of badges, and the evaluation and control methods. R. S. Landauer, Jr. & Co.

Circle No. 36, Pages 145-146

Metal ceramic pyrometer sheaths . . . are very refractory, have cold strength about that of cast iron and excellent shock resistance. Sheaths can be plunged straight into molten metal without danger of cracking. Morganite Research & Development, Ltd.

Circle No. 37, Pages 145-146

Electronic searching information . . . for technical articles, documents, and patents on metals and related subjects is discussed in eight-page brochure. American Society for Metals.

Circle No. 38, Pages 145-146

Shell mold release agents . . . promote easier stripping of cured shells from pattern. Re-useable sprayers are either air charged by standard compressed air chucks or auxiliary carbon dioxide bombs. Milwaukee Sprayer Mfg. Co.

Circle No. 39, Pages 145-146

Gray iron mold coating . . . for centrifugal castings promotes gray as-cast structure with type A graphite and encourages directional solidification. Leaflet outlines applications and benefits. Foseco, Inc.

Circle No. 40, Pages 145-146

Metal-filled silicone resins . . . show promise of answering many design problems at low and high temperatures. Available with fillers of lead, bronze, steel, copper, and aluminum. Furane Plastics, Inc.

Circle No. 41, Pages 145-146

Dust control methods . . . are outlined in 20-page bulletin. Basic essentials comprising a typical dust control system are outlined. Pangborn Corp.

Circle No. 42, Pages 145-146

Impregnating material . . . reportedly gives nearly 100 per cent casting recovery with one application. Contains inert fillers equal in dimension to porosity of casting. Decreases in size from a comparative few at 0.0016 in. down to a large quantity at 0.00004 in. Frederic B. Stevens, Inc.

Circle No. 43, Pages 145-146

High-strength castable refractory . . . for pneumatic gun placement features low rebound loss and minimum dusting. Produces high strength monolithic body with high resistance to abrasion and thermal shock. Babcock & Wilcox Co.

Circle No. 44, Pages 145-146

Self-setting binder . . . eliminates need for heat or CO_2 gassing to cure cores and molds of any size. Working sample available. Para Products Div., Foundry Rubber, Inc.

Circle No. 45, Pages 145-146

New additive . . . reportedly improves stainless steel and other alloy ingots. Said to purge out oxygen and hydrogen during pouring, minimizing scalding and pitting. Crane Packing Co.

Circle No. 46, Pages 145-146

Portable drafting kit . . . can be carried or stored in desk or table. Provides advantage of T-square, triangle and protractor, all combined into self-contained binder housing which automatically locks. National Blank Book Co.

Circle No. 47, Pages 145-146

Alumina refractory plastic . . . fire brick has high fusion point which resists flux action of scale. It is highly resistant to penetration or adherence of metal. Designed for

Get it fast from

BERKSHIRE CHEMICALS Inc.

630 Third Ave., New York 17, N. Y.

Sales Offices: New York • Chicago • Camden • Cleveland • Boston • Pittsburgh • San Francisco

Circle No. 171, Pages 145-146

use in crucible covers, ladles, soaking pits, and reheat furnaces. Kaiser Refractories & Chemicals Div., Kaiser Aluminum & Chemical Corp.

Circle No. 48, Pages 145-146

Hydraulic cylinders . . . developed to meet rugged use, heat, and dirt encountered in foundry operations. Available in a wide range of sizes for ladle, shakeout, conveyor, shell casting, and other foundry operations. Milwaukee Cylinder Co.

Circle No. 49, Pages 145-146

Letters and figures . . . catalog includes trademarks and monograms formerly available from Canton Products, acquired in 1960. H. W. Knight & Son, Inc.

Circle No. 50, Pages 145-146

Dry lubricant . . . grease-type, is designed for extreme pressure applications. Bulletin shows applications and lubricating characteristics. Alpha-Molykote Corp.

Circle No. 51, Pages 145-146

Core binders . . . for high volume, high speed foundry operations consist of new fast-curing modified liquid phenolic resins and accelerators. Simple wet mix requires only resin, accelerator, and sand—prepared in standard muller. Durez Plastics Div., Hooker Chemical Corp.

Circle No. 52, Pages 145-146

Flask upsets . . . for increasing height and strength of flasks are described in two-page catalog. Hines Flask Co.

Circle No. 53, Pages 145-146

Furnace gas analyzer . . . provides direct trend recording of up to eight components in a gas mixture operating on the principle of gas chromatography. Gives a complete analysis every five minutes. Research & Control Instruments, Inc.

Circle No. 54, Pages 145-146

Processes

Permanent mold process . . . produces iron manhole ring frames weighing 200 lb. Hourly production is five. Process will handle molds for producing iron, aluminum, and copper-base alloys. Wagner Permanent Mold Co.

Circle No. 55, Pages 145-146

Ultrasonic flaw detector . . . features operation without liquid coupling reportedly required in most units. The ultrasonically-vibrating crystal in the device is intimately coupled to the object to be tested through the medium of a newly-developed synthetic membrane which fits tightly over the transducer. Oil need not be cleaned off from tested objects. Ultrasonic Div., Circo Corp.

Circle No. 56, Pages 145-146

Wet blasting . . . for finishing die castings, scale removal, degreasing, and similar applications are contained in 24-page illustrated handbook. Lord Chemical & Equipment Div., Wheelabrator Corp.

Circle No. 57, Pages 145-146

Pad washing time . . . cut 25 per cent in steel foundry. Year long survey discloses that carbon rods with tapered ends have lowered both time and costs. Speer Carbon Co.

Circle No. 58, Pages 145-146

Dye penetrant inspection . . . made easier to use with pressure cans. Locates cracks and defects invisible to unaided eye and marks them. Eight-page bulletin outlines uses. Magnaflux Corp.

Circle No. 59, Pages 145-146

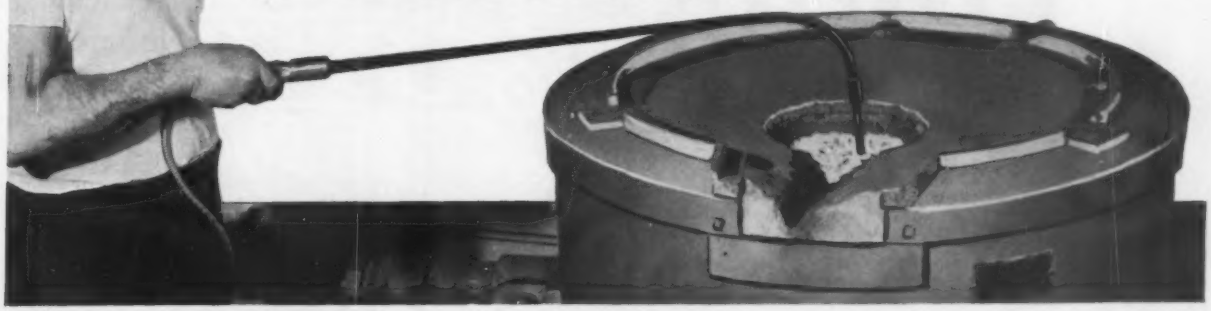
FAST, ACCURATE, DEEP READINGS

Marshall Thermocouples Promote Castings Quality!

Marshall Enclosed-Tip Thermocouples assure strong, dense, uniform castings from every nonferrous melt! Tip can be immersed 3 inches to 30 inches or more in depth and stirred to speed pyrometer reading. You get accurate temperature from deep within melt in about 20 seconds! Hot junction tip, armored with enclosing tube of special alloy, withstands scores of immersions before low-cost replacement is necessary. Thermocouple wire can't be contaminated from melt or shortcircuited by slag! Rugged, well-balanced Marshall Thermocouples are convenient to carry and use, simple and economical to operate. Available as Furnace Type (below) in lengths up to 10 feet, for use with Stationary Pyrometer . . . or Ladle Type for use with Portable Pyrometer.

. . . write today for Free Catalog!

L. H. MARSHALL CO. 270 WEST LANE AVE. COLUMBUS 2, OHIO



Circle No. 166, Pages 145-146

Whitehead Brass Joins In Marine Research

Whitehead Brass Foundry, Inc., Brooklyn, N. Y., is participating in a joint research venture with New York Testing Laboratories, Inc., N. Y. A 50-foot vessel added by New York Testing will be used as a floating laboratory to test marine electronic items, corrosion protection devices, and de-salting processes.

New Chevrolet Foundry

A new manufacturing development foundry building is being constructed at Saginaw, Mich., as part of the Chevrolet-Saginaw Grey Iron Div. of General Motors Corp. The plant, expected to be in operation in about a year, will be housed in a separate building about 28,000 square feet.

Dominion Brake Makes Purchase

Dominion Brake Shoe Co., Ltd., wholly-owned Canadian subsidiary of American Brake Shoe Co., has acquired a minority interest in Jarry Hydraulics, Ltd., Canada's leading producer of aircraft landing gear and steering systems, and major manufacturer of other airborne hydraulic equipment. The purchase was made for an undisclosed amount of cash.

The acquisition will give Dominion Brake Shoe a broad base in the fields of aircraft and missile hydraulic systems. Two American Brake Shoe divisions currently manufacture hydraulic products in the United States.

Birdsboro Forms Division

Birdsboro Corp., Birdsboro, Pa., formed a Chemical Machinery Div. to manufacture a broad range of chemical process equipment and special purpose machinery. This is another step in the company's diversification program. Products of the new division, Birdsboro's eighth, will be manufactured at the company's Reading, Pa., plant.

New G. E. Smith Licensee

G. E. Smith, Inc., Pittsburgh, Pa., producers of binders and chemicals for the foundry industry, has signed a second license agreement with a European manufacturer. Agreement has been reached with Vereingte Chemiche Fabriken—Kreidl, Reuter & Co., Austria, for the manufacture of its no-bake binder and hot box binder.

Moves and Additions

Sawbrook Steel Castings Co., Cincinnati, has broken ground for a $600,000 addition to its plant facilities. The new section, approximately 60x373 ft., is being erected to the present foundry and will increase the plant area by 20 per cent.

Cleveland Crane & Engineering Co. . . . Wickliffe, Ohio, has established a West Coast Tramrail Division at 6435 Corvette St., Los Angeles.

Northwestern Metal Co. . . . Lincoln, Nebr., has broken ground for a new automated non-ferrous smelter. The 67,000 sq. ft. plant will be in full operation by Nov. 1.

Willard Bronze Co. . . . Cincinnati, has opened a new manufacturing plant in Graham, N. C. The facility has 35,000 sq. ft. devoted to manufacturing precision and permanent mold castings.

DIETERT DETROIT

automation equipment for production sand systems

Sand, Core, Shell and Mold Testing Equipment

CARBON and SULFUR DETERMINATORS

DIETERT DETROIT

DIETERT DETROIT

HARRY W. DIETERT CO.
9330 ROSELAWN AVE.
DETROIT 4, MICHIGAN

Circle No. 172, Pages 145-146

EMPIRE*
"THAT GOOD"
FOUNDRY COKE

DEBARDELEBEN COAL CORPORATION
2201 First Ave., North Birmingham 3, Ala.
Phone ALpine 1-9135

*Reg. U. S. Pat. Off.

Circle No. 173, Pages 145-146

STATEMENT OF OWNERSHIP

Statement required by the act of August 24, 1912, as amended by the Acts of March 3, 1933, and July 2, 1946 (Title 39, United States Code, Section 233) showing the ownership, management and circulation of MODERN CASTINGS, published monthly at Lafayette, Ind., for September 1, 1961. 1—The names and addresses of the publisher, editor, managing editor, and business manager are: Publisher, American Foundrymen's Society, Golf & Wolf Roads, Des Plaines, Ill.; Editor, Jack H. Schaum, Golf & Wolf Roads, Des Plaines, Ill.; Managing Director, Harold E. Green, Golf & Wolf Roads, Des Plaines, Ill. 2—The owner is: American Foundrymen's Society, Golf & Wolf Roads, Des Plaines, Ill. Organized not for profit, without stock. Principal officers: President, Albert L. Hunt, Superior Foundry Inc., Cleveland, Ohio; Vice-President, John A. Wagner, Wagner Castings Co., Decatur, Ill.; General Manager, Wm. W. Maloney, American Foundrymen's Society, Golf & Wolf Roads, Des Plaines, Ill.; Secretary, Ashley B. Sinnett, American Foundrymen's Society, Golf & Wolf Roads, Des Plaines, Ill.; Treasurer, Edward R. May, American Foundrymen's Society, Golf & Wolf Roads, Des Plaines, Ill. 3—The known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are none. 4—Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner. Harold E. Green, Managing Director. Sworn to and subscribed before me this 7th day of September, 1961 (seal). E. R. May, notary public. (My commission expires March 14, 1964.)

Classified Advertising

For Sale, Help Wanted, Personals, Engineering Service, etc., set solid . . 35c per word, 30 words minimum prepaid. Positions Wanted . . 10c per word, 30 words minimum, prepaid. Box number, care of Modern Castings, counts as 10 words. Display Classified . . Based on per-column width, per inch . . 1-time, $22.00 6-time, $20.00 per insertion; 12-time, $18.00 per insertion; prepaid.

HELP WANTED

MALLEABLE FOUNDRY & LIAISON MAN—Must be experienced in foundry operations such as pattern layout work, foundry scrap control, and customer service-sales contacts. State age, education, experience, employment records and salary expected. **Box J-103 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Illinois.**

CHIEF METALLURGIST (Malleable Iron)—degree or equivalent—experience in malleable iron melting and heat treating. Knowledge of sand technology, gating, pattern layout, etc. highly desirable. Attractive salary for qualified man. **Write: Personnel Department, Lancaster Malleable Castings Co., 1170 Lititz Avenue, Lancaster, Pa.**

ASSISTANT SUPERINTENDENT — Must be able to assume full responsibility and supervision of producing miscellaneous types of small gray iron castings. Job will require full knowledge of cope and drag work, match plate, pouring, sand control and core work. This is an excellent opportunity for the right man between the ages of 35 and 45 for future advancement. Send full resume of past experience and salary requirements to: **Personnel Director, Muskegon Piston Ring Company, E. Gardner Street, Sparta, Michigan.**

CHEMIST—For Smelting and Refining company to analyze non-ferrous metals and alloys. Modern chemical and spectrographic laboratory. Permanent position. Salary open. Write giving full details on background and ability to: **Box I-103 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SALES REPRESENTATIVE

We are interested in securing the services, on a salary plus basis, of an aggressive sales engineer to contact and sell the foundry trade. Must have a metallurgical background or equivalent practical foundry experience. Our company is prominent in its field, presently selling a widely used product to all types of foundries.

Man desired should not be over 40 years of age, preferably 30 to 35, free to travel extensively. Headquarters in a medium size Midwestern town with moving expenses paid.

Send complete resume on education and experience and salary requirements. All inquiries held in strictest confidence. Please reply to **Box I-101 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Illinois.**

WANTED — SUPERINTENDENT Gray Iron Foundry Midwest employing 300. Must be top man experienced in automotive, agriculture type casting and jobbing. Excellent opportunity. Send all particulars to **Box J-104 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRYMEN

when you need SUPERVISORY or TECHNICAL men why not consult a man with actual foundry experience plus 15 years in finding and placing FOUNDRY PERSONNEL

Or if you are a FOUNDRYMAN looking for a new position you will want the advantages of this experience and close contact with employers throughout the country.

For action contact: John Cope

DRAKE PERSONNEL, INC.
29 E. Madison St., Chicago 2, Illinois
Financial 6-8700

WANTED
MACHINE DESIGN ENGINEER

Wide experience in one or more of the following fields: Earth Moving Equipment, Powered Farm Equipment, Mining Equipment, or Foundry Machinery. B.S. degree in Engineering with five (5) years experience or equivalent required. Please give details of qualifications, experience, salary range, and availability in first letter. All inquiries will be held in strict confidence.

DESIGN DRAFTSMEN

Experienced in electrical and mechanical drafting and design. Degree not required. To work on design of heavy foundry equipment. Please give details of qualifications, experience, salary range, and availability in first letter. All inquiries will be held in strict confidence.

TYLER PIPE & FOUNDRY COMPANY
P. O. Box 2027
Tyler, Texas

POSITION WANTED

GRADUATE METALLURGIST, with supervisory experience carbon, alloy and stainless steels, molding, melting, processing and heat treating, seeks broader horizons. **Address: Box I-105 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

MANAGEMENT POSITION sought by experienced (17 years) Metallurgist, well rounded in arc and induction melting all steels, molding, processing, heat treating, estimating and casting design. **Reply c/o Box J-105 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

Experienced NON-FERROUS CHEMIST, wet and spectrochemical analysis. Capable of setting up new laboratory or assisting management. Broad background. **Box J-106 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SUPERINTENDENT OR GENERAL FOREMAN, 45 years old. Non-ferrous 20 years supervisory experience in captive and jobbing work: well versed in all foundry operations. Presently employed as Foundry Superintendent. Good reference. Desire change for personal reasons. Resume on request to **Box F-102 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

PERMANENT MOLD FOUNDRYMAN—Graduate Engineer, experienced and capable in all phases of light metals permanent mold casting, seeks responsible position. **Reply Box No. J-101 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY ENGINEER—B.S. Met. E. Age 40. Eighteen years aluminum, magnesium foundry experience. Process, alloy development, methods, all phases pilot production. Sand, permanent mold, plaster process, specializing in high strength, high precision. Wants challenging management or engineering position with progressive organization. Resume on request. **Box J-102 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

METALLURGICAL ENGINEER—Experienced in steel and iron foundry operations. Complete working knowledge of sand control and melting practices. Experienced in supervision. Age 37 and married. Qualified to assume full control of foundry operation. **Please send inquiries to Box J-100 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOR SALE

FOR SALE—One Model 2½F Simpson Mix-Muller, approximately 40 cu. ft. capacity, complete with dust hood and 60 HP motor. Excellent condition. Used 3 years. **Address Box I-107 S, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

PRACTICALLY NEW CENTRIFUGAL CASTING MACHINES manufactured by National Supply in 1942-46 (1) 36″ pipe cap. x 18′ long max., min. 8″ x 18′ long. (1) 10″ pipe x 12′ long max., min. 2″ x 12′ long. Water cooled. Complete w/aux. equip., motors, pushers, pouring car, etc. **BELIEVED BRAND NEW, NEVER USED. The Eveready Supply Company, 805 Housatonic Avenue, Bridgeport 4, Conn. Phone: EDison 4-9471.**

QUALITY EQUIPMENT
SAVE AT LEAST 50%

Blast Cleaning
15″ cont. Wheelabrator Tumblast
36″ x 42″ Wheelabrator Tumblast
18GN Pangborn Blastmaster Late
Furnaces
3000# Detroit Ind. Arc. Mltg.
210 KW Lindberg Heat Treat
1½ Ton Arc Melting Furnace
500# Induction Melting Inst.
Sand Mullers
Simpson #3, U.D., 30 cu. ft.
Simpson #2, U.D., 14 cu. ft.

Complete stock of foundry equipment. Send for free illustrated catalog.

UNIVERSAL Mach'y & Equip't Co.
Box 873, Reading, Pa. FRanklin 3-5103

The Editor's Forum . . . . .

Many a company . . . is judged by the employees it keeps and American Radiator Standard Sanitary Corp. can be proud of its record at the Louisville foundry. The average length of service for all foundry employees is better than 25 years! All are entitled to four weeks vacation period a year, so the foundry closes down for three weeks in July and one week during the Christmas holidays. When you hear about all their extracurricular activities you can appreciate why Louisville Standard foundry is a good place to work. Company sponsors an industrial and a white-collar softball team, and a combined basketball team—all three won first place in the city championship tournaments. There's two bowling leagues, golf tournaments, dances, and sponsorship of a Boy Scout Troop, Sea Scout Troop, and a Junior Achievement Program.

"Materials handling conveyors . . . give us all the mulling action we need for our synthetic sand system," says Floyd Wilhelm, general foreman of the brass shop at The Kennedy Valve Manufacturing Co. Floyd showed me how they mixed binder materials into new sand with a muller from which wheels had been removed. Only the plows stir the mix. The system sand is continually self-mulled at is moves around and around through the shop by reciprocating conveyors, bucket elevators, track conveyors, belts, and aeriating spinner. Sand is used in making brass and bronze valves and stems on jolt-squeeze machines. This is certainly one way to avoid over-mulling.

Man-saving . . . in every foundry means looking for work that one man can do where it once took two. International Harvester's Louisville foundry now has fork lift truck operators fill their own transfer ladle from the cupola forehearth. Electric switch hangs beside him when the truck, holding transfer ladle, is in position to receive metal from forehearth. Push buttons let him tilt and pour into his ladle. Now there's no need for an extra man to handle this job.

F. A. Osterman, general foundry superintendent, International Harvester foundry, believes that automation and man-saving create new jobs, not lay-offs. He was quick to point out that the man eliminated was transferred to other duties.

Have you ever . . . run into a core so tricky it defied shell core box design? Take the core needed for a transmission housing. Albion Malleable Iron Co. solved this problem by breaking complex shape down into two relatively simple shapes. They blow one part of the core and use it as an insert in their second core box. Second core is blown so that it welds to the first core resulting in one integral piece. Bill Truckenmiller at Albion explained that this saves tedious hand pasting of two cores together, subsequent paste drying, and eliminates inaccuracies of alignment. Two simple boxes are cheaper to build than one complicated with sliding inserts and draw backs. This thinking could be extended to build up cores involving even more than two pieces.

Micro-mottle . . . is a new defect we never knew we had. But ultrasonics has provided another quality control tool that can reveal metal characteristics once invisible to the probing metallurgist. John Bryce at Albion tells me that ultrasonics sets the metalcasting industry on the threshold of a new quality control breakthrough. By revealing micro-mottle in malleable iron, producers can guarantee quality and weed-out defective stowaways. The fact that you can probe every cross-section of a casting with penetrating sonics and get an immediate evaluation makes this testing technique especially attractive. There are no lethal radiation problems involved. The potential value is not limited to malleable iron, since it can be use on any metal and has already proven a valuable aid in measuring casting wall thickness, especially where core shifts are a problem.

Jack Hickman

dependable Molybdenum in the foundry

Primary justification for increased success in foundry applications of molybdenum is found in the dependability of results. Day after day the foundryman gets the results he needs by adding molybdenum to his melt. Molybdenum may be added to improve tensile and transverse strength, increase impact and fatigue strength, improve wear resistance, increase toughness and strength at higher temperatures, intensify effects of other alloying elements.

The consistency of results in production justifies confidence in MCA molybdenum.

MCA closely controls all of its manufacturing steps and the chemistry of its molybdenum products, hence the uniformity of results.

Complete stocks of molybdenum in all of its metallurgical forms are available through MCA. Technical assistance in meeting tough specifications or solving specialized problems is yours upon request. No obligation, of course.

MOLYBDENUM

CORPORATION OF AMERICA

1312, Building Number 4, Gateway Center, Pittsburgh 22, Pa.

Offices: Pittsburgh, Chicago, Los Angeles, New York, San Francisco
Sales Representatives: Brumley-Donaldson Co., Los Angeles, San Francisco
Subsidiary: Cleveland-Tungsten, Inc., Cleveland
Plants: Washington, Pa., York, Pa.

Circle No. 173, Pages 145-146

RCI

Creative Chemistry ... Your Partner in Progress

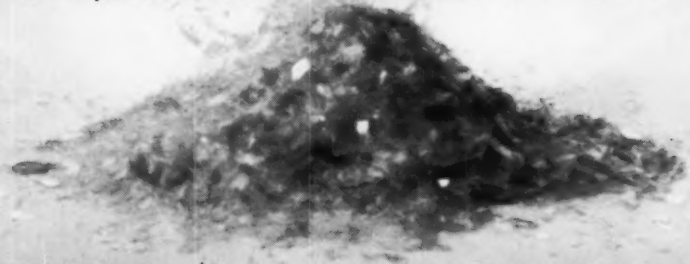
NOW A NEW HOT-COATING RESIN IN FLAKES

FOUNDREZ 7520F—the new sand coating novolac in thin-flake form.

Made for fast, solvent-free hot-coating of dry sand for shell molds and cores. **1.** Shortens coating cycle as much as 30% over crushed types. **2.** Eliminates explosion hazard. **3.** Minimizes dust present in crushed or powdered forms. **4.** Provides uniform coating by uniform particle size and uniformity of manufacture.

Get more facts on the "flake" resin that can help you in coating—RCI's FOUNDREZ 7520F. Write to RCI Foundry Division for Technical Bulletin F-2-Rc. Reichhold Chemicals, Inc., RCI Building, White Plains, N. Y.

REICHHOLD



REICHHOLD Foundry Products: FOUNDREZ • Synthetic Resin Binders • Self-Curing Binders • Core Oils • Sand Conditioning Agents.